MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXX. FEBRUARY 13, 1920. No. 4

ANNUAL GENERAL MEETING.

Professor FOWLER, F.R.S., PRESIDENT, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The Report of the Auditors of the Treasurer's accounts for the year 1919 was read, and is given on p. 340.

The Annual Report of the Council was partly read.

The President announced that the present Meeting was the hundredth anniversary of the Society, and delivered an Address dealing mainly with the foundation and early history of the Royal Astronomical Society. The Address is given on p. 440.

It was proposed and carried that the Report of the Council be received and adopted, and that it be printed and circulated in the usual manner, together with the Report of the Auditors and the President's Address.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 451.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Christopher Patrick Adamson, Lieut. (late R.A.F.), Corleone, Longham, Wimborne, Dorset;

Clement Osborn Bartrum, B.Sc. Lond., 32 Willoughby Road, Hampstead, N.W. 3;

Frederick E. Brasch, Assistant Reference Librarian, John Crerar Library, Chicago, U.S.A.;

Sidney Bertram Gaythorpe, 3 Prospect Road, Barrow-in-Furness;

James Hargreaves, Bennington, Stevenage, Herts;

John Johnston Ross, M.A. (Glasgow), B.A. (Lond.), Vice-President, West of Scotland Branch, British Astronomical Association, 7 Queen's Terrace, Glasgow, W.;

Miss Dorothy Wrinch, Lecturer in Mathematics, University College, London,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Leonard Berger Benny, M.A., Head of the Mathematical Department, University College, Exeter (proposed by S. Brodetsky);

Violet Mary Common, 62 Ranelagh Road, Ealing, W. 5 (proposed by A. Fowler);

J. P. Henderson, M.A., Dominion Observatory, Ottawa, Canada (proposed by Otto Klotz);

Donald William Horner, F.R.Met.Soc., Glendale, Tower Park, Moretonhampstead, Devon (proposed by W. F. Denning);

Harold Lee Parker Jolly, M.A., Ordnance Survey Office, Southampton (proposed by F. J. M. Stratton);

Elizabeth Isis Kent (*née* Pogson), formerly Assistant to the Government Astronomer at Madras (1873–1896), and Meteorological Reporter (1884–1896), "Velindre," 213 Holdenhurst Road, Bournemouth (proposed by H. H. Turner);

William Reginald Kirkwood, Stoke House, Seaford, Sussex (proposed by Andrew Russell Forsyth);

Henry Lowery, B.Sc. (Lond.), F.R.Met.Soc., Science Master (Physics), County Secondary School, Claydon-on-Tyne, 18 Montreal Street, Cleator Moor, Cumberland (proposed by C. M. Fleming); and

J. Horace Reeves, M.A., M.B.E. (Military), 6 Penywern Road, Earl's Court, S.W. (proposed by Theodore E. R Phillips).

Report of the Council to the Hundredth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Patron	Honorary Member	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1918 December 31	1	1	224	465	52	743
Since elected	...	...	+4	+43	+1	...
Deceased	...	...	−7	− 9	−3	...
Resigned	...	...	...	− 5	...	...
Since compounded	...	...	+ 5	− 5	...	...
Removed from list	...	...	...	− 1	...	...
Restored to list	...		...	+ 1	...	...
1919 December 31	1	1	226	489	50	767

(Six Associates are also Fellows, and are therefore counted twice in the above table.)

Mr. Knobel's Account as Treasurer of the Royal

RECEIVED.	£ s. d.	£ s. d.
Balances, 1918 December 31:—		
At Bankers', as per Pass-book	205 3 3	
In hand of Assistant Secretary on Petty Cash Account	1 15 8	
In hand of Assistant Secretary on account of Turnor and Horrox Fund	0 14 5	
		207 13 4
Received on account of Dividends:—		
£1,250 Metropolitan 3-per-cent. Stock ...	26 5 0	
£2,000 Swansea Corporation 3½-per-cent. Stock	49 0 0	
£3,500 East Indian Railway 3-per-cent. Debenture Stock	73 10 0	
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	73 10 0	
£4,000 Midland Railway 2½-per-cent. Debenture Stock	70 0 0	
£1,000 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock	21 3 9	
£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock	50 8 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	42 0 0	
£1,352, 12s. 6d. War Loan 5-per-cent. Inscribed Stock	67 12 6	
		473 9 3
Received on account of Subscriptions:—		
Arrears	222 12 0	
Annual Contributions for 1919	711 18 0	
,, ,, ,, 1920	12 12 0	
Admission Fees	102 18 0	
First Contributions	82 19 0	
		1132 19 0
Compositions		247 16 0
Sales of Publications:—		
At Society's Rooms	14 9 6	
At W. Wesley & Sons' £124 2 5		
Less 10 per cent. discount 12 8 2		
	111 14 3	
Herschel's Works: half share, received from the Royal Society	2 0 0	
		128 3 9
Sales of Photographs		41 15 3
Franklin-Adams Chart		10 10 0
London Mathematical Society, for use of Rooms ...		20 0 0
Income Tax refunded by Commissioners of Inland Revenue		169 2 8
Sir David Gill Bequest		250 0 0
Cheques outstanding, 1919 January 1		17 3 6
Cheque outstanding, 1919 December 31		3 0 0
Excess on Cheque and French Money Order ...		0 2 2

Examined and found correct.
(Signed) P. J. MELOTTE.
P. H. HEPBURN.

£2,701 14 11

Astronomical Society, from 1919 *January* 1 *to December* 31.

PAID.

	£ s. d.	£ s. d.
Assistant Secretary: Salary	250 0 0	
,, ,, Editing Society's Publications	50 0 0	
Clerk: Salary (2 quarters) £50 0 0		
Less Army pay 34 13 6		
	15 6 6	
Assistant Clerk: Salary	109 4 0	
Porter and wife: Wages	123 10 0	
		548 0 6
House Duty	2 12 6	
Insurance of Stock at printers'	1 18 3	
Servants' Insurance Stamps	1 6 0	
		5 16 9
Printing, etc.:—		
Monthly Notices	974 19 5	
List of Fellows and Miscellaneous	74 10 0	
Photo-engraving	58 17 4	
		1108 6 9
Reproduction of Photographs for sale		30 10 8
Turnor and Horrox Fund: Purchase of Books for Library		15 12 3
Expenses of Meetings of R.A.S.	17 16 1	
,, ,, ,, Geophysical Committee ...	7 19 4	
Time Signal: Rental of Wire	5 0 0	
		30 15 5
Telephone Subscription	6 10 0	
Registration of Telegraphic Address	1 1 0	
Postage, etc. (including postage of Monthly Notices)	92 1 4	
Carriage of Parcels	0 17 3	
Stationery and Office expenses	13 14 5	
		114 4 0
House expenses	17 5 1	
Coal, Gas, and Electric Light	101 5 6	
Sundry fittings and repairs	15 10 11	
Sundries	4 9 1	
		138 10 7
Insurance of portrait of Sir David Gill		0 9 0
Subscription Bureau Internat. pour Telegrammes Astronomiques (2 years)		4 4 8
Subscription Conjoint Board of Scientific Societies		10 0 0
Lee and Janson Fund Grants		12 0 0
Assistant Secretary for work for London Mathematical Society	10 0 0	
Expenses of Meetings of London Mathematical Society	5 2 0	
		15 2 0
Purchase of £275, 16s. 5-per-cent. War Loan Registered Stock		250 0 0
Cheque book and charges on cheques	1 1 5	
Deficiency on French P.O. Orders	0 2 0	
		1 3 5
Cheques outstanding, 1919 January 1		13 13 0
Cheques outstanding, 1919 December 31		16 4 0
Balances, 1919 December 31:—		
At Bankers', as per Pass-book	370 12 9	
In hand of Assist. Sec. on Petty Cash Account	11 7 0	
,, ,, on Account of Turnor and Horrox Fund ...	5 2 2	
		387 1 11
		£2,701 14 11

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1919, and have found and certified the same to be correct. The cash in hand on 1919 December 31, including the balance at the bank, etc., amounted to £387, 1*s.* 11*d.*

The funded property of the Society has been increased by the purchase of £275, 16*s.* 0*d.* 5-per-cent. War Loan 1929/4/7 Registered Stock, purchased with the Sir David Gill bequest of £250.

The books, instruments, and other effects appear to be in a satisfactory condition.

A list has been laid on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

The certificates of railway and other stocks have been examined, and the stocks inscribed at the Bank of England verified.

(Signed) P. J. Melotte.
P. H. Hepburn.

1920 *February* 13.

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1919 Jan. 1. Balance of Fund	41	2	4	1919. Grants from Fund	12	0	0
1919. Dividends, East Indian Railway ...	10	0	9	1919 Dec. 31. Balance of Fund	39	3	1
	£51	3	1		£51	3	1

The Turnor Fund and the Horrox Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrox: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1919 Jan. 1. Balance of Fund	9	16	1	1919. Purchase of Books	15	12	3
1919. Dividends, East Indian Railway ...	17	1	0	1919 Dec. 31. Balance of Fund	11	4	10
	£26	17	1		£26	17	1

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1919 Jan. 1. Balance of Fund	38	0	5	1919 Dec. 31. Balance of Fund	47	6	5
1919. Dividends, East Indian Railway ...	9	6	0				
	£47	6	5		£47	6	5

The Sir David Gill Bequest: The following is an extract from the Will of the late Sir David Gill:—

> I direct my Trustees and Executors to pay to the Royal Astronomical Society of London (the receipt of the Secretary for the time being a full and efficient discharge) the sum of Two hundred and fifty pounds to be employed by the Council of the said Society in aid of Astronomical Research, and I desire to declare that I make this bequest in grateful remembrance of a like sum paid out of the funds of the said Society in aid of my expedition to Ascension in the year one thousand eight hundred and seventy-seven, and I express a wish that the said sum be devoted in part or in whole to some expenditure of a like character to complete some great work, such as the computation of New Tables of the Satellites of Jupiter or other like undertaking of fundamental importance to Astronomy, but I expressly provide and declare that the same shall not be applied to Eclipse Expeditions, as these are now recognised as objects which are provided for by Government or other funds.

This sum now stands in £275, 16*s.* 0*d.* 5-per-cent. War Loan Registered Stock.

Assets and Present Property of the Society, 1920 January 1.

	£	*s.*	*d.*	£	*s.*	*d.*
Balances, 1919 December 31:—						
At Bankers', as per Pass-book	370	12	9			
In hand of Assistant Secretary on Petty Cash Account	11	7	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	5	2	2			
				387	1	11
Due on account of Subscriptions:—						
1 Contribution of 4 years' standing	8	8	0			
15 ,, 3 ,, ,, ...	94	10	0			
35 ,, 2 ,, ,, ...	147	0	0			
58 ,, 1 ,, ,, ...	121	16	0			
Other sums	6	19	0			
	378	13	0			
Less Contributions paid in advance	12	12	0			
				366	1	0
Due for Photographs sold				0	17	0
Due from Wm. Wesley & Son for sales of Publications during the last quarter of 1919				11	19	0

£1,250 Metropolitan 3-per-cent. Stock.

£2,000 Swansea Corporation 3½-per-cent. Stock.

£3,500 East Indian Railway 3-per-cent. Debenture Stock.

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock.

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£1,000 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,352 12s. 6d. War Loan 5-per-cent. Inscribed Stock.

£275 16s. 0d. War Loan 5-per-cent. Registered Stock.

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

Two Gold Medals.

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.

285–287. Solar Corona, 1918 June 8, Lick Observatory Expedition.

288. Cluster M 13 Herculis, J. S. Plaskett, Dominion Astrophysical Observatory, British Columbia.

289. Annular Nebula *Lyra*, J. S. Plaskett, Dominion Astrophysical Observatory, British Columbia.

290. Progressive Spectra of *Nova Aquilæ* 1918, Rev. A. L. Cortie.

291. Solar Corona, 1919 May 29, A. C. D. Crommelin and C. Davidson.

292. Solar Prominence, 1919 May 29, A. C. D. Crommelin and C. Davidson.

293. Portion of Moon (Tycho to Ptolemæus), Mt. Wilson Observatory.

294. ,, ,, ,, (S. Pole to Albategnius), Mt. Wilson Observatory.

295. ,, ,, ,, (Mare Imbrium), Mt. Wilson Observatory.

296. 100-inch Reflector, Mt. Wilson Observatory.

297. Halley's Comet and Venus, 1910, Johannesburg Observatory.

298. Spectra, Halley's Comet and Venus, 1910, Kodaikánal Observatory.

Publications of the Society.

During the past year vol. lxxix. of the *Monthly Notices* has been published.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—Francis Benjamin Allison.
James Law Challis.
James Cook.
Reginald Francis Dale.
Frederic Hammond.
Daniel Hogarth.
Bertram F. E. Keeling.
William Evan M'Farlane.
James M'Kerrow.
George James Newbegin.
Lord Rayleigh.
Thomas Roseby.
Roberto Rossi.
Walter Sidgreaves.
Charles Stevens.
Charles Thomas Whitmell.
Associates :—Baron Roland Eötvös.
Edward Charles Pickering.
Annibale Riccò.

Francis Benjamin Allison was born in 1840 at Ilford in Essex, where his father was at the time the only medical practitioner. He was educated at Forest School and at a school in Kensington, and later entered Sidney Sussex College, Cambridge, where he graduated as 27th Wrangler and also obtained a first-class in natural science. After taking priest's orders in 1865 he obtained a mastership at Brighton College, and from 1865 to 1878 was mathematical master at Derby Grammar School. In 1885 he took a small private school in Eastbourne, but in 1893 he accepted the college living of Peasmarsh in Sussex, where he remained till his death.

He was a man of very wide tastes and attainments. From his early days he was fond of experiments, in his eager desire to get at the truth of things for himself rather than rely merely on the authority of others. His astronomical work consisted largely in making observations of the moon with a $4\frac{1}{2}$-inch telescope, and in conjunction with Mr. Gray of Bedford he made a special study of the formation Archimedes.

He was a very keen and able musician, and composed a good many things in a light style. He was also a diligent student of Oriental languages, being much interested in their construction.

For years he worked at Chinese most thoroughly, and he leaves a large collection of Chinese books. Latterly he devoted a great deal of attention to the gyroscope and wireless telegraphy, and up to the day of his death he showed his unfailing interest in scientific matters by discussing the Einstein theory.

In his Cambridge days he threw himself energetically into boating, and joined the Rifle Volunteers. He was also a great walker, and in his vacations explored North Wales most thoroughly, especially the Snowdon district. Throughout his life he was blessed with excellent health, and never had a serious illness till quite the end. He passed away peacefully in his sleep on 1919 December 8, only two days before his friend Mr. C. T. Whitmell.

In 1869 he married Eliza Walton, who died two years ago. He leaves one daughter, Mrs. A. ffoulkes.

He was elected a Fellow of the Society on 1880 November 12.

James Law Challis was born on 1833 October 4th at Papworth Everard Rectory, Cambs., being the only son of the Rev. James Challis, F.R.S., Plumian Professor of Astronomy in the University of Cambridge. He was educated at Marlborough and at Trinity College, Cambridge He took his degree as fifteenth senior optime in 1856. After taking his degree he acted as assistant to his father at the Cambridge Observatory. He was appointed to the curacy of Arrington, near Royston, in 1858. In 1859 he accepted the curacy of All Saints, Huntingdon. In 1860 he was presented to the living of Papworth Everard by Trinity College, which he held till 1879, when he was offered the living of Stone, near Aylesbury, in the gift of the Royal Astronomical Society. Mr. Challis was for many years Rural Dean of Aylesbury and was associated with much of the Oxford diocesan work. He was a devoted parish priest and greatly beloved by his parishioners. His winter evening lectures on Astronomy, given in the parish room, were always greatly appreciated—he considered the giving of these lectures a duty he owed to the Royal Astronomical Society. In 1916 he resigned the livings of Hartwell and Stone (the livings had been united in 1902) and came to live at Exmouth, where he died on 1919 November 11. He was taken to Stone for burial and laid to rest under the shadow of the church he loved so much, and which had been beautifully restored through his untiring energy. He was elected a Fellow of the Society on 1879 November 14.

James Cook was born at Lancaster, 1839 June 15. He was engaged upon his father's farm before he attained his teens, but being well educated as training went in those days, he was attracted to astronomy at an early age. He commenced the construction of telescopes, and was later encouraged in this work by the friendship of James Nasmyth and the appreciation of Lord Lindsay. He was very successful in his optical work and produced fine reflectors up to 18 inches aperture and some small

refractors, with their eye-pieces and other accessories. It was not until he had passed his fortieth year that James Cook began to use the lathe, in which he became highly proficient. He resided for a considerable time at Preston, and whilst there was the first to arrange for the illumination of clock faces, and also suggested the setting up of the first clock with heavy single lines at the hour spaces in place of numerals. In 1884 he journeyed to New South Wales to act as mechanician at the Sydney University. Here he worked for 25 years and produced many pieces of refined apparatus for the Physics Laboratory. Ten years ago he suffered from an attack of double pneumonia and had since been an invalid from bronchial troubles. During this long period he seldom complained, and found a great solace in reading and conversation with friends. His wife predeceased him many years, and he leaves no children. He died at Leichhardt, Sydney, 1919 September 6, in his eighty-first year.

He was elected a Fellow of the Society on 1881 January 14.

The Rev. Reginald Francis Dale was the youngest child of the Rev. Thomas Dale, a former Dean of Rochester, and was born on 1845 September 12. He was educated at Blackheath Proprietary School and Queen's College, Oxford, where he gained an Open Mathematical Scholarship in 1863, and took a degree in Honours both in Mathematics and Classics. In 1870 he joined the staff of Westminster School, acting generally as master of a classical form, but gave subsidiary help in the higher school mathematics. He took Holy Orders in 1870, and in 1886 left Westminster to occupy the living of Bletchington, Oxford, where he was Rector until 1899. He held other livings in the diocese up to the year 1911, and was Rural Dean of Islip during the period 1894–1899. In 1899 he was appointed Mathematical Lecturer at Keble College, Oxford, and held this post until 1918. Mr. Dale was an accomplished musician, both in practice and theory, and took the degree of B.Mus. of Oxford. He joined the Society, perhaps at the instigation of his colleague at Westminster, Mr. Cheyne, the author of two well-known astronomical text-books. Mr. Dale did not marry. He died from a weakness of the heart on 1919 November 14.

He was elected a Fellow of the Society on 1871 June 9.

H. P. H.

Frederic Hammond was born at Warley, near Brentwood, Essex, on 1847 January 7. By profession he was an architect and surveyor, being in private practice for many years, and latterly serving as district surveyor for Hampstead. For a long time he was Governor of the Great Northern Central Hospital, and a Trustee of the Cloudesley Estate. He also took a deep interest in church work, holding the office of Churchwarden at St. John's, Upper Holloway, for 9 years, and at St. George's, Tufnell Park, during the 18 years preceding his death.

He was a man of many and varied interests, but his favourite

hobby was astronomy. At one time he possessed a good reflecting telescope and more recently a refractor, but, in addition to his observing, he frequently gave popular lectures on subjects relating to astronomy.

He married Temperance Canning Snowden, a descendant of George Canning the statesman. He died on 1919 June 6, leaving a widow, three sons and two daughters, all his children being married.

He was elected a Fellow of the Society on 1895 January 11.

Daniel Hogarth was born at Bentham on 1842 April 25, and died on 1919 February 3 at Sydney, N.S.W., where he had lived for about 40 years, though paying several visits to the Old Country during that time. He was a man of the most charitable disposition, and during the severe distress at Bradford in 1878 he rendered much assistance in making provision for those in need. On going out to Australia he devoted himself whole-heartedly to the welfare of New South Wales.

On the occasion of his visit to England in 1912 he interviewed several leading men in reference to a proposal for the establishment of stations in the Arctic regions from which timely warning might be given of the break up and drifting away of ice masses such as had caused the disaster to the *Titanic*.

The matter was sympathetically discussed, and some time after he had returned to Australia the Liverpool *Journal of Commerce* stated that communications were passing between the Government and the principal Atlantic Steamship Lines with reference to the sending into the N. Atlantic a suitably equipped vessel with a wireless installation. He himself strongly favoured the establishment of fixed stations.

Among his other interests and hobbies astronomy took first place, and he possessed and used a fine telescope.

He was elected a Fellow of the Society on 1914 February 14.

Lieutenant-Colonel B. F. E. Keeling was born in 1880, and was educated at Bradford Grammar School, thence proceeding to Trinity College, Cambridge, where he obtained firsts in the Natural Science and Mechanical Science (Engineering) Tripos.

On leaving the university he was for a short time at the Royal Arsenal, Woolwich, and then joined the staff of the National Physical Laboratory, where most of his work was done in the department of Metrology.

In 1904 he joined the Survey of Egypt, where he took charge of the Major Triangulation and carried out the design and erection of a comparator for verifying and controlling the base-measuring apparatus. In 1905, on the occasion of the Solar eclipse, Keeling had charge of all the arrangements at Aswan for facilitating the work of those astronomers who observed the eclipse at that station. Shortly after this he took over the Helwân Observatory near Cairo, and in this year and the next devoted much of his

time and attention to the erection of the 30-inch reflector which Mr. J. H. Reynolds had generously presented to the Egyptian Government. From this time onwards, though his interest in astronomy and his zeal for its advancement in Egypt never flagged, geodetic and physical investigations made increasing demands upon him. Under his direction a chain of first order (geodetic) triangulation was carried for some 500 kilometres up the Nile Valley, precise levelling was extensively carried out over the Delta and along the Valley, while in connection with this a gravity survey was executed along the Nile from the Mediterranean to Khartoum.

The amount of shipping passing through the Suez Canal and the short stay of vessels at Port Said and Suez make accurate time-signals there of great importance, and in 1906–7 Keeling took the matter in hand and reorganised the existing system so that the clock of the observatory should control and actuate the time-signals given at Cairo, Port Said, and Alexandria.

In 1914 his work in Egypt was interrupted by the war and he received a Commission in the Royal Engineers, being employed in France with the Survey Companies. He was wounded in 1916, but returned to France in 1917, being present at the Somme battle, the attack on Cambrai, the German attack in 1918 and our subsequent advance, where his tact and technical skill were of great value throughout the survey operations. In the spring of 1919 he returned to Egypt to take up the direction of the Survey Department, and had already made arrangements for resuming the geodetic and other work which the war had interrupted. He died there on 1919 September 25.

Full of energy, capable in administration, and equipped with a sound scientific training, his death is a severe loss to Egypt, where his abilities were fully recognised and highly esteemed.

He was elected a Fellow of the Society on 1907 November 8.

H. G. L.

William Evan M'Farlane was born in England in 1866. He entered the medical profession, and after first practising for a short time in Edinburgh travelled for a few years and then settled in China. During the South African War he served as medical officer in the British Army, and subsequently obtained a Government appointment in Queensland. He was very keenly interested in Astronomy, and some few years ago set up an observatory equipped with a 7-inch Cooke equatorial, which he employed in the measurement of double stars and the observation of occultations. He died on 1919 August 18.

He was elected a Fellow of the Society on 1919 January 10.

James M'Kerrow was born at Kilmarnock, Scotland, on 1834 July 7, but the greater part of his life was spent in New Zealand, where he settled at the end of 1859 November. The extent to which he was identified with the development of the Dominion can be gathered from a brief summary of his professional career.

He was appointed on the survey staff of Otago very shortly after his arrival, and for two years was engaged in the settlement surveys in the survey districts of North Harbour and Blueskin, Otokia, Waipouri, Maungatua, Taieri, and Moeraki. From 1861 December to 1863 October he was engaged in the reconnaissance survey of over four million acres of the back mountain country of Otago, including the Hawea, Wanaka, Wakatipu, Mavora, Te Anau, Manapouri, Monowai, and Hauroto Lakes. For the next three years he was Geodesical Surveyor. In 1866 September he was appointed Inspector of Land and Mining Survey, and continued in that office until 1873, when he became Chief Surveyor of Otago. In 1876 November, on the abolition of the Provincial Governments, he was appointed Assistant Surveyor-General for the Colony, in 1878 Secretary for Crown Lands and Mines, and in 1879 Surveyor-General. In 1889 January he was appointed Chief Commissioner of Railways, and held that position for six years. He was then appointed Chairman of the Board of Land Purchase Commissioners, holding that office for several years until 1901 December 31, when he retired.

He served also as a member of the Midland Railway Commission, and Chairman of the Land Commission in 1905. He was also a director of the Gear Company for some years, and Chairman of the Wellington Trust, Investment, and Agency Company. He was also a prominent member of the Presbyterian Church, and the senior elder of St. John's Church. He was twice married, and is survived by his second wife and two daughters by his first wife.

That he was a man of exceptional ability in his profession is shown by the many high positions which he held in the Civil Service, and the public records are proof of the invaluable services that he rendered to the Dominion. The years of arduous work that are comprised in the brief record of his professional activities in the early days demonstrate to the full the loyalty, grit, and solid determination that he possessed and displayed in the carrying out of expert and scientific work at a time when means of communication were of the most primitive description, and when the surveying of the mountainous forest lands of the South necessitated the finest qualities that man can possess. But, intent only on doing his duty, he carried out his responsible work unappalled by dangers which rarely cross the path of a professional man, and won through to a healthy old age, with mind unimpaired, and with a bodily vigour that only the process of years could affect. Reticent and retiring to a degree, he was content with having done to the best of his ability the work that came to his hand—and it is a record of which any man might be proud. He died on 1919 June 29.

He observed the Transit of Venus in 1882, and was elected a Fellow of the Society in December of that year.

George James Newbegin was born at Norwich in 1845, and educated at Priory School. At an early age he was apprenticed

to a firm of booksellers and stationers at Tunbridge Wells. From there he returned to Norwich to assist his father in the business of tobacco manufacturing.

He early manifested a love for astronomy, and about 1875 erected his first telescope—a 5-inch equatorial—in a quadrangle of the factory. This was about 35 feet square, the walls being 30 feet high, and admitted of only a very limited horizon. To overcome the difficulties of the situation the telescope was mounted on a very high pillar. In 1882 he moved to Thorpe St. Andrew and re-erected his telescope in beautiful grounds overlooking the river Yare. In 1888 he purchased a fine 9-inch Cooke equatorial, together with a dome 22 feet in diameter, and for sixteen years devoted much of his time to the study of solar phenomena, both visual and photographic. In the early nineties he parted with his 5-inch instrument and replaced it with a $4\frac{1}{4}$-inch Cooke photo-visual, which has done good work in other hands besides his own. Not being able to take part in total solar eclipse expeditions himself, he was ever ready to lend the instrument to some astronomer who could go, and, in 1898, Mr. C. Thwaites, M.Inst.C.E., F.R.A.S., took it to India, and in 1901 Mr. E. W. Maunder had the loan of it for Mauritius. In 1905 Mr. Thwaites again used it on the Spanish expedition.

In 1904 October Mr. Newbegin moved to Sutton, Surrey, taking the 9-inch with him and mounting the photographic lens alongside. It was there perhaps that his most serious work was accomplished, for he started a series of spectroscopic observations on solar prominences which were continued to the close of his life, the results being published in the *Journal of the British Astronomical Association* and latterly in the *Monthly Notices* as well.

The instrumental side of astronomy appealed strongly to Mr. Newbegin, and many improvements of his own design were carried out on his equipment. It was always a great pleasure to him to show anyone interested something through his telescope, and for many years his observatories at Thorpe were open to the public on Easter Monday. On one occasion 241 persons passed through the observatories.

He was quiet and somewhat reserved in manner, and for recreation indulged in walking, and was very fond of chess problems. In his earlier life his sporting instincts led him to take up yachting.

He died on 1919 April 4, leaving one son. He served for several years on the Council of the British Astronomical Association, and was many times appointed an Auditor of the Society's accounts.

He was elected a Fellow of the Society, 1888 April 13.

John William Strutt, 3rd Baron Rayleigh, was born in 1842. As a child he was extremely delicate, and was not able to go through the ordinary public school education. He was prepared for the university by Mr. Warner, who took pupils

at Torquay. In 1861 he went up to Trinity College, Cambridge, where he gained the Sheepshanks Exhibition for astronomy. He graduated as Senior Wrangler in 1865, and was elected to a Fellowship at Trinity College in 1866. He did not, however, undertake any college teaching work. His private circumstances left him free for scientific pursuits, and to these he devoted a life of almost unremitting labour.

Lord Rayleigh could scarcely be called an astronomer, though he always took an interest in some branches of the subject. Much of his work had little or no astronomical bearing, but other parts bore closely on the work of astronomers, and it is to these latter that attention will here be drawn. Other more general accounts of his career have appeared, *e.g.* in *Nature*, to which reference may be made.

A paper appears in the *Monthly Notices* for 1872 (33, 59–63) on "The Diffraction of Object Glasses," in which it is proposed to block out the centre rather than the circumferential parts of an object glass used on the sun, so as to reduce light without loss of resolving power. The idea was, however, less novel than the author then thought. A central stop increases the diameter and intensity of the diffraction rings, and calculations of this effect were given. This was the only paper he presented to the Society.

In his early experimental work much attention was paid to the duplication of diffraction gratings by photography (contact printing). From boyhood onwards he had become expert in the various photographic processes which were in vogue before the use of silver-gelatine plates, and indeed throughout life he took more pleasure in photography and its scientific applications than in any other kind of experimental technique. These early processes give a very fine grain, well adapted to the problem. Very successful reproductions of the early glass gratings by Nobert and Rutherfurd were obtained. They were not appreciably inferior to the originals in resolving power, and some of them gave much brighter spectra, owing, no doubt, to a more favourable width of the opaque bars in the copy. Rowland's speculum gratings, far superior to their predecessors, appeared shortly afterwards, and these did not lend themselves well to photographic reproduction; thus the method has not been of much actual service. If the proposal to make transparent objective gratings for large telescopes should be realised, a better field for Rayleigh's methods of reproduction might be found.

These experiments on gratings brought the author's mind into intimate contact with the subject, and suggested the train of thought which led to some of his most important optical work, the work by which he is perhaps best known to astronomers: this is his theoretical study of the resolving power of spectroscopes. Without attempting any critical study of the state of opinion on such matters at that time (1879), it is enough to say that it was extremely vague and confused. For example, in the case of gratings there was a notion among spectroscopic workers

that the abrupt limitation of the grating aperture had an unfavourable effect on definition, and that a great improvement might be obtained if this abruptness could be in some way rased off. Again, in the case of prism spectroscopes no clear notions were entertained of the distinction between the angular dispersion and the resolving power of spectroscopes, though the analogous problem for the telescope was well understood, at least by some.

In Rayleigh's treatment of the subject, the separation of two close spectrum lines was comparable with the separation of two double stars in the telescope. The resolving power was defined as the ratio of the whole wave-length to the smallest difference that could just be detected. The latter was taken as a definite displacement of the diffraction pattern. For the grating the resolving power was shown by quite simple considerations to be equal to the product of the order of spectrum examined and the total number of rulings.

In his experimental work he had occasionally obtained photographic copies of gratings which threw a less fraction of the light of a soda flame into the central image than into the first-order spectrum on either side. This was at the time an unexpected result, and, as he pointed out, it showed that the gratings in question could not act merely by blocking out part of the wave-front, but that they must introduce differences of phase. This conception is now familiar, and has its highest development in Michelson's echelon.

His theory of the prism spectroscope was also the result of experimental suggestion. In testing the performance of his grating copies, the very superior results they gave compared with a prism raised in his mind the question of what the essential condition is for high resolving power. The dispersive power of the glass used must of course enter. But what more? The answer generally given at that time would almost certainly have been the number of prisms used, assuming them of course to be of the largest angle practicable. He showed by an argument of characteristic simplicity and directness that the resolving power for a given glass depended solely on the aggregate length of glass traversed at the thick ends of the prisms, assuming of course that the beam was broad enough to extend to their thin ends. The numerical resolving power was found to be simply the product of this thickness by the dispersive power. No consideration is more essential to the design of spectroscopes than this. Indeed, the matter is so simple and fundamental, that it now seems a matter of surprise that it was not discovered earlier in the history of optics.

In the same series of papers is discussed the question of what error of phase is admissible in optical instruments without appreciably distorting the diffraction pattern, and thus doing harm to the resolving power. The question is not of course one which admits of a perfectly precise answer, but it was shown that in many important cases an extreme error of $\frac{1}{4}$ of a wave-length does no appreciable harm, but beyond this the definition suffers. This

rule, which has stood the test of time, is of great value in practical optician's work, as it shows the limit beyond which improved accuracy is not necessary or useful in figuring the surfaces of objectives or mirrors, as the author pointed out shortly before his death. It is important to avoid the mistake of applying this rule blindly, and without due discrimination as to the limitations under which it holds. It would, for example, be altogether beside the mark to apply it to instruments of the interferometer class, where the requirements are much more exacting.

Another of Rayleigh's optical investigations may be mentioned: this concerns the broadening of spectrum lines as conditioned by the Doppler effect of moving molecules. He drew attention to this in 1873, though the idea had been mooted three years earlier by Lippich. Rayleigh, however, was the first to show quantitatively what would be the limit to interference on this basis. This line of thought has been developed by Fabry and Buisson, and has led in their hands to an interesting determination of the effective temperature of the great nebula in Orion.

Rayleigh's best-known work is of course the discovery of argon, which resulted from his accurate weighings of gases. Sir William Ramsay collaborated in the later stages of the work, which led afterwards in the hands of the latter to the isolation of terrestrial helium.

Rayleigh wrote on many other subjects which bear directly or indirectly on astronomical work, such as the origin of the blue sky, stellar scintillation, and the rationale of the grinding and polishing processes of the optician.

Most of his work was carried out at his country seat, Terling Place, near Witham, Essex, where he had a laboratory distinguished by the homely simplicity of the appliances used. During the years 1880–1884, however, he was Professor of Experimental Physics at Cambridge, and worked mainly at the Cavendish Laboratory. Afterwards (1887–1905) he was Professor of Natural Philosophy at the Royal Institution, and worked there during a part of the year.

He served as President of the Royal Society for the years 1905–1908. A characteristic sentence from one of his Presidential Addresses may be worth quoting. Referring to Hale's discovery of the Zeeman effect in sun-spots, he said, "Until we understand better than we do these solar processes, on which our very existence depends, we may do well to cultivate a humbler frame of mind than that indulged in by some of our colleagues."

Rayleigh married in 1871 Miss Evelyn Balfour, sister of the Rt. Hon. A. J. Balfour. He had four sons, of whom two survive. He died after an illness of a few weeks on 1919 June 30.

Many honorary distinctions were accorded to him. Amongst others, he was one of the original members of the Order of Merit, and Chancellor of the University of Cambridge.

He was elected a Fellow of the Society on 1866 January 12.

R.

Thomas Roseby was born in Sydney, New South Wales, 1844 April 8. He had a brilliant career at Sydney University, where he held three scholarships and a Fellowship of Camden College. In 1868 he was Gold Medallist in Logic and Mental Science, in 1871 he obtained the M.A. and LL.B. degrees, and two years later the LL.D. Dr. Roseby became widely known as one of the leading ministers of the Congregational Church. He was the first minister of the Petersham church from 1867 to 1871, and then went to New Zealand, where for thirteen years he had charge of the Dunedin church. From 1885 to 1888 he laboured at Ballarat in Victoria, and then became minister at Marrickville, a populous suburb of Sydney, where he was pastor for twenty-three years. He was endowed with a most generous spirit, keen insight, strong faith, and wide sympathies. All his life he took a deep interest in scientific, social, and educational matters: he was a constant worker for the education and advancement of the people. His sermons showed independence of thought and fearless advocacy of truth, and frequently dealt with those political and social questions which are now assuming such serious importance. Astronomy and Botany were his favourite scientific studies; in the former he attained high proficiency. His observational work was limited by the many calls upon his time, and was principally devoted to such double stars as were within the range of his 4-inch refractor. His computation of "Elliptic Elements of Comet Gale, 1894 II." was published in *M.N.*, 56, 329. His store of knowledge was very great and was always available to aid the student. As a member of the New South Wales Branch of the British Astronomical Association, and several times its president, he was ever ready to forward the interests of astronomy, and by means of monthly notanda kept the members informed of the latest progress. Dr. Roseby attained the highest offices in his Church and was Chairman of the Australasian Congregational Union from 1913 to 1916. He occupied similar positions in the New South Wales Union in 1891 and 1903, and was delegate to the International Conference in London in 1891. He married in 1871, and is survived by his widow and five sons and four daughters. He enjoyed good health throughout his life and preached to within a few weeks of his death, which took place after a brief illness from pneumonia, 1918 December 16.

He was elected a Fellow of the Society on 1895 January 11.

W. F. G.

Roberto Rossi was the son of Signor Gaetano Rossi, a member of the Italian Parliament. He came to England in 1906, and graduated in the research course at Manchester in 1909. In that year he had completed a valuable piece of work on the effect of pressure on the band spectra of the fluorides of the metals of the alkaline earths. This work, which was published in the *Proceedings of the Royal Society* (82, 518), showed that these bands, in which Dufour had recently detected the Zeeman effect, are

displaced by pressure. He worked with W. G. Duffield on the spectrum emitted by silver in a carbon-tube furnace (*Ap. J.*, 28, 371). In 1910 he was elected to a Research Fellowship at Manchester; and continuing the work which Duffield had so successfully inaugurated, he studied the effect of pressure on the arc spectra of titanium (*Proc. R.S.*, 83, 414) and of vanadium (*Ap. J.*, 34, 21), and also on the widening of the hydrogen lines (*Ap. J.*, 34, 299). In 1912 he went to Cambridge, and carried out further researches in the astrophysical department of the observatory. He had there studied the widening of the hydrogen lines under different conditions of electrical excitation in the spark spectrum (*Ap. J.*, 34, 299), and had begun work on the displacement of lines in the sun's spectrum. He joined the expedition to the Crimea to observe the total eclipse of the sun in 1914 August. On his return to his native land he got a commission in the Engineers, and was soon afterwards, in 1915, attached to the Italian Navy in scientific work, to which he devoted himself at Venice until the end of the war. A life of great promise was cut short by his death on 1919 March 17.

He was elected a Fellow of the Society on 1913 January 10.

H. F. N.

Father Walter Sidgreaves, S.J., died at Stonyhurst College on 1919 June 12, after a lingering illness borne with exemplary patience, at the ripe age of 82 years. He was born 1837 October 4, the second son of Edward Sidgreaves, of Grimsargh, near Preston, Lancashire. He came to Stonyhurst as a boy in 1848, and, after completing his school course, joined the Society of Jesus on 1855 September 7. He returned to Stonyhurst in 1857, to the seminary attached to the College, and remained there until 1861, when he had completed his literary and philosophical studies. He then taught for seven years at the College: in 1862–65, chemistry and mathematics; and in 1866–68, mathematics.

In the period 1863–68 he acted as director of the observatory while Father Perry was engaged in his theological studies. Father Perry had succeeded Father Weld in the direction of the establishment in 1860. The observatory, which was founded in 1838, was primarily intended as a meteorological station, and the readings of the usual instruments have been continuously recorded since that date. The year 1866 marked an interesting period in the development of the Meteorological Office, for in that year its functions were transferred from the Board of Trade to a Committee of the Royal Society. This was followed by the establishment of seven observatories of recording instruments of uniform pattern to provide material for the scientific study of the weather. Stonyhurst was chosen as one of the seven stations, and Father Sidgreaves installed the photographic barograph and thermograph, the anemometer and the rain gauge. The experiment terminated in 1884, when the weather service was reorganised on a different system.

In the year 1858 Sir Edward Sabine, who was then making

a magnetic survey of England, chose Stonyhurst as one of his observing stations. The next year Father Weld, who had purchased a set of instruments for the observation of the absolute values of the magnetic elements, commenced these records at Stonyhurst. But it was Father Sidgreaves who in 1863 inaugurated the regular series of monthly determinations of the magnetic elements, which have been continued uninterruptedly since that date. For the last twenty years also he had taken most of the observations himself. His very last observation, made when he could scarcely walk to the observatory, was of the magnetic dip on 1919 May 3. His pluck was indomitable.

In 1866, still during his first directorship of the observatory, he installed and adjusted in a specially constructed subterranean chamber the set of self-recording photographic magnetographs, generously presented to the observatory by the Royal Society. In connection with his interest in terrestrial magnetism he accompanied Father Perry, and with him made a magnetic survey of the west and east of France, during his long vacations, when he was studying theology, in the years 1868–69.

One of the most important papers which he published (*Mem.*, *R.A.S.*, 54, 85) was "On the Connection between Sun-spots and Earth-magnetic Storms." It contains a discussion, based on a very great number of measures of the areas of sun-spots from the long series of drawings accumulated at Stonyhurst, and of the ranges in the magnetic elements from the photographic records, as to the precise nature of the connection between sun-spot area and terrestrial magnetic disturbance. The study covers the period 1881–1898. The conclusion he arrived at was that the connection was not one of direct cause and effect. He further suggested that both the spots on the sun and the magnetic storms on earth were due to clouds of electrified particles which existed between the sun and the earth.

As with meteorology and with terrestrial magnetism, so too with astronomy the main equipment of the observatory is due to Father Sidgreaves. In 1867 the 4-inch refractor, which was the first instrument systematically used by Father Secchi when he resided at Stonyhurst during the revolutionary troubles in Italy in 1848, was replaced by an 8-inch refractor. This again, during Father Sidgreaves' second directorship of the observatory, 1890–1919, was furnished with a 15-inch object-glass as a memorial to Father Perry, subscribed for by his friends.

After the completion of his theological studies and his ordination as priest in 1871, Father Sidgreaves returned to Stonyhurst in 1873, when he acted as assistant to Father Perry, and accompanied him on the British Government expedition to observe the transit of Venus at Kerguelen Island on 1874 December 9. The astronomers were conveyed from the Cape of Good Hope to the desolate island which was to be their abode from 1874 October 8 to 1875 February 27 in H.M.S. *Volage*, which was propelled by steam helped by sails. They experienced a succession of heavy

gales, the seas on several occasions coming clear over the bulwarks and submerging the guns. Father Perry used to declare that Father Sidgreaves, who worked in snow and sleet and violent winds, was magnificent. He set up all the instruments, took most of the magnetic observations, and contributed greatly to the success of the expedition. He again accompanied Father Perry, in the year 1882, to observe the second transit of Venus at Nos Vey, Madagascar, the astronomers being assisted on this occasion by the officers and crew of H.M.S. *Fawn*.

On the death of Father Perry, on board H.M.S. *Comus* during the total solar eclipse expedition to Cayenne of 1889 December, Father Sidgreaves resumed the charge of the Stonyhurst Observatory. At that time he was superior of the scholasticate, 1881 to 1893, at St. Mary's Hall, Stonyhurst, a kind and gentle superior beloved by all his subjects. To this office, from the year 1883, he joined that of professor of experimental physics, which he taught for twenty-two years. As a professor he was remarkably up to date, by no means antiquated or stereotyped. Every new discovery was illustrated in his lectures, which were intended to make the future priests conversant with the trend of the scientific thought of the day. His manipulative skill in performing experiments was remarkable. By nature his mind was sceptical, and it took a great deal of unimpeachable observational data to convince him.

Father Sidgreaves' original researches in astronomy are contained in many papers published in scientific periodicals, but more especially in the *Monthly Notices* of the R.A.S. In solar physics, one of the chief studies he made was of a long series of photographs of the violet rays of calcium in the sun's spectrum. For this purpose he took hundreds of photographs of the H and K region of the spectrum in the general light of the sun with the fine Hilger spectrograph which had been acquired by Father Perry. The result was to prove that the sun is akin to that class of stars which show both bright and dark lines in their spectra, and is itself spectroscopically a variable star. Contrary to the usually accepted theory he held also, from a study of the series of Stonyhurst drawings, that the umbræ of sun-spots are elevations and not depressions below the sun's luminous envelope or surface.

But he will be chiefly remembered for his researches on the spectra of stars. Working with instruments of greatly inferior power to those possessed by many observatories, spectrographs which he had designed himself, he obtained a long series of very beautiful spectra. He was a most painstaking, methodical, and accurate observer. This photographic work was awarded a gold medal at the St. Louis Exposition of 1904, and a grand-prix in the Franco-British Exhibition of 1908.

His memoir on the "Spectrum of Nova Aurigæ," 1892 (*Memoirs, R.A.S.*, 51, 29), contains a long list of bright and dark lines measured in the spectrum of the star, and is a very valuable contribution to our knowledge of the constitution of new stars.

Nova Aurigæ was the first new star the spectrum of which was photographed, and Father Sidgreaves was one of the first observers to obtain such photographs. He recognised the similarity between the spectrum of the star and that of the solar chromosphere. He was equally successful with his photographs of the new star in Perseus, 1901, and more particularly demonstrated the change in the spectrum which sympathetically accompanied its alternations in luminosity when it had attained a magnitude about 4·57.

Among other stars of which he published spectroscopic studies were β Lyræ, o Ceti, and γ Cassiopeiæ. These papers are illustrated by some beautiful reproductions from his original photographs, in particular the plate which shows the connecting star links between Secchi's Type II. and Type III., and by valuable detailed descriptions, accompanied by tables of wave-lengths of the particular stars studied. He has left hundreds of plates of the spectra of the brighter stars, which await measurement and discussion. In the case of β Lyræ he broached an ingenious theory on the cause of the variability in its light which he expounded in a lecture delivered before the Royal Institution in 1904. (*Proc. R.I.*, 1904.)

The character of Father Sidgreaves exhibited many of the traits of the typical Lancashire man. He was very tenacious of purpose, and very orderly and methodical in his work. In advancing years he became very deaf, and he made his deafness an excuse for shunning public appearances, which were naturally distasteful to him. He was happiest when he was working in his observatory, and in this work he was indefatigable. For the last nine years he had practically given up astronomical work with the exception of the time service, but terrestrial magnetic work he kept in his own hands until the very end. When we remember that, during his directorship of the observatory, he joined with his astronomical work the office of Superior of a large community and a professorship of physics, it is certainly remarkable that he was able to accomplish so much, although he possessed a very strong and hardy constitution.

He was one of the most kindly and gentle of men, most charitable in his judgments of others, and most courteous and urbane to all with whom he came in contact. He was revered by his own brethren in religious life as a model of exactness. "A good old man. His memory will remain treasured by all of us who knew him," writes the Astronomer Royal, and this verdict may well serve as his epitaph. He lies buried at Stonyhurst, with which college by far the greater part of his long life had been identified, as boy and man, and which he loved and served so faithfully.

He served for several years on the Council. He also acted for a term of years as President of the North-Western Branch of the British Astronomical Association at Manchester, and for two years as the director of its solar spectroscopic section.

He was elected a Fellow of the Society on 1891 January 9.

A. L. C.

Charles Stevens was born at Dalston in 1852, and died at Ipswich on 1918 December 1.

In 1900 he entered the General Post Office, Secretary's branch, where he held an appointment for many years.

In 1906 he left London to take up duties as postmaster at Peterborough, where he remained three years, before going on to Ipswich. He retired in 1914.

He was twice married, and had two daughters and one son, who at present holds an appointment in the Indian Civil Service.

Apart from his official duties, he was most interested in music and astronomy.

He was elected a Fellow of the Society on 1899 February 10.

Charles Thomas Whitmell was born at Leeds on 1849 July 10, his father holding an appointment in the Leeds branch of the Bank of England. He attended the Leeds Grammar School, where he won a prize for Inorganic Chemistry in 1864. He received a letter of encouragement from Faraday about that time which he carefully preserved. At the age of nineteen he gained the degree of B.Sc. at London University. A year later he went to Cambridge, having obtained a Scholarship in Natural Science at Trinity College, Cambridge. In 1872 he was tenth Senior Optime in the Mathematical Tripos and first in the First Class in the Natural Science Tripos. He remained for some years taking pupils and giving University Extension Lectures. For two years he was a master at Tonbridge School. In 1879 he commenced the principal professional work of his life, being appointed Inspector of Schools under the Board of Education; his field of work was at Sheffield for a short time, then at Cardiff, where he remained till 1897; he was then transferred to his birthplace, Leeds, and remained here for the rest of his life, retiring, however, from his professional work in 1910. He was held in the highest respect and esteem by all the teachers of the schools which he visited for his courtesy, considerateness, and charm of manner.

His love for nature and science remained throughout his life. He found opportunities for travel in the Alps, Norway, United States, etc. Many notes made on these occasions were incorporated in his useful handbook on colour, published in 1888. Phenomena of colour greatly interested him, and he wrote several notes in explanation of the green flash at sunset, the white appearance of the moon in daylight, etc. He had in his house a variety of apparatus for producing curious colour effects. In astronomy also his bent lay in the direction of calculating unusual or unexpected phenomena. The transit of the half-lit moon over the half-lit earth as seen from Mars may be mentioned, also the fact that some of Jupiter's satellites can produce three total eclipses at the same conjunction to a point on the planet's surface. His series of "View Point" papers brought out many relations of this kind, and are very instructive.

He contributed papers to the *Monthly Notices*. One (70, 455) is on the maximum duration of totality in a solar eclipse, which is found to be $7^m\ 40^s$. Another describes the eclipse of 1900 May 28, which he observed from Navalmoral, Spain.

He also contributed numerous papers to the Journal of the British Astronomical Association, being for some time on the Council of that body.

While at Leeds he did much to forward the work of two societies there: the Leeds Literary and Philosophical Society, which has just celebrated its centenary (Sir John Herschel lectured to it in 1858); and the Leeds Astronomical Society (to which Sir John Herschel delivered his lecture, "The Yard, the Pendulum, and the Metre," in 1863). This society passed into a state of suspended animation, but was revived about 1892. Whitmell was in turn president of both these societies; for many years he edited the Journal of the latter, and contributed liberally to the cost of its production. Altogether he exercised a powerful influence for the encouragement of scientific study; this showed itself, *inter alia*, in the patient, careful manner in which he dealt with the difficulties of inquirers in the columns of the *English Mechanic*.

He had a great love of literature and poetry, and some skill in composing verses. He married in 1903, Lucy, the sixth daughter of the late Sir William Foster, Bart., of the Grove, Hardingham, Norfolk; she shared his tastes, and they became acquainted on the occasion of the eclipse expedition to Spain in 1900. During the war she wrote the poem, "Christ in Flanders," which became widely known and appreciated both at home and in the trenches. She died in 1917 May, leaving no children.

Whitmell carried on his normal work till within a few days of his death. He caught a chill early in December, to which he succumbed on December 10, at the age of 70.

He will be widely missed by a large circle of friends, who welcomed his interesting and stimulating letters. The replies to these letters were carefully preserved and bound by him, forming a valuable record which deserves a place in some reference library.

He was elected a Fellow of the Society on 1898 December 9.

A. C. D. C.

Edward Charles Pickering was not an old man, as astronomers reckon old age, being only 73 at the time of his death on February 3 last; but he was our oldest living medallist, and with one exception our oldest living Associate. He had directed one of the leading observatories of the United States for nearly half a century, increasing its prosperity and output of work to an extent of which he himself can scarcely have dreamed when he took charge in 1877, and it is safe to say that if he had been free to choose any career the world has to offer, he would have chosen to be what he was.

He was born on Beacon Hill in Boston, 1846 July 19, his father being the grandson of Timothy Pickering of Salem, who

graduated from Harvard in 1763, and his mother's maiden name being Charlotte Hammond. He graduated from the Lawrence Scientific School of Harvard University at the age of 19, and at 21 was appointed Thayer Professor of Physics in the Massachusetts Institute of Technology. Here he did notable pioneer work. We have almost forgotten how novel an institution a physical laboratory was in the seventies. Balfour Stewart started a laboratory at Manchester in 1870, and the Cavendish Laboratory at Cambridge dates from 1874. Kohlrausch's book on physical measurements was first published in 1869. These few dates suffice to show the novelty and importance of the opening of the "first physical laboratory in the United States" in 1869 October by the young professor of 23; it is not surprising to learn that some of his experiments adumbrated the telephone.

But he was soon called to his lifework at the observatory, being appointed Director by President Eliot in 1876, in succession to Joseph Winlock, and thenceforward he seldom left his home and work, though meetings with other astronomers could sometimes tempt him away, especially in his later years. Thus he came to Europe for some months in 1913, taking part in the Bonn meeting of the Solar Union and spending some time in London and Oxford; but in 1900, when he had intended a similar participation in the meeting of the Astrographic Chart Committee at Paris, the pull of Harvard proved too strong. For a few days he managed to amuse himself at the Paris Exposition of that year, especially with various automatic machines, then somewhat new; but at last he could bear it no longer, and he returned to his beloved observatory, leaving Mrs. Pickering to represent him at the gathering. His eclipse expeditions (1869 and 1870) belong to the pre-observatory days; when once he had taken charge, the corona seemed to him an entirely overrated attraction, and he did not hesitate to state this opinion in print. His life-history in the ordinary sense can thus be completed in a very few words. He married in 1874 Lizzie Wadsworth Sparks, daughter of Jared Sparks, a historian and a former president of Harvard. Mrs. Pickering died in 1906, and there was no family. The home of the Director and his wife was made a temporary but delightful home for many visitors from all parts of the world, and especially for astronomers.

But if it is easy thus to summarise the main incidents in a life of devoted and happy toil, it is the more difficult to give a real idea of what was accomplished. "Pickering was content to think of himself and to be what he called 'a collector of astronomical facts'" (Rev. J. H. Metcalf, *V.J.S.*, **54**, 4), but then he collected facts by the million, as he also collected dollars to spend in collecting the facts. He raised the endowment of the observatory to a million dollars, and he himself made a million and a half photometric measures. It was super-collecting. No mere share in the sky would content him, he must photograph the whole sky, south hemisphere as well as north; nay, he must photograph it many

times over, so that for any part of it there are 100 plates or so in the Harvard collection. The writer of these words has just had the experience of failing to confirm a suspected large proper motion for lack of plates differing in date; three were available, but all taken within 18 months. Had a mere fraction of the Harvard Reference Library of photographs been available in England, the confirmation could have been easily obtained. Pickering's plan has not been copied elsewhere, but sooner or later we shall probably copy it, and shall regret the time lost in doing so. Meanwhile it may safely be said that for studying the recent history of the universe there is material at Harvard which cannot be approached elsewhere.

But it would be quite erroneous to regard it as raw material. Much of it has been worked over with great care, often by novel methods devised for the purpose, and the result has been an immense crop of discoveries of all kinds—novæ, variables, spectroscopic binaries, peculiar spectra, and so on. Twice as many variables have been discovered at Harvard as in all the history of astronomy elsewhere. In addition, the adopted classification of spectra may fairly be regarded as a product of wholesale dealing. Other astronomers have proposed systems of classifying spectra: and it is possible that we have not yet arrived at a final choice. But the Harvard system has been adopted for use and found worthy of the adoption, and in considering its origin and comparing it with other systems we cannot but remember that it was based on the examination of a much larger number of spectra than others. The spectra were on a small scale, and might be considered rough in comparison with the beautiful results obtained for special stars by other workers with larger instruments: but they were numerous enough to fill in all the gaps and show the sequence clearly; and it is interesting to note the paradox that from the study of these small scale spectra, which might have been expected to give only qualitative results, there has emerged a numerical scale—a quantitative measure of spectral quality, already in use for numerical comparison with temperatures and other quantitative characters. Pickering took but little interest in the measures of stellar or planetary positions, which form so large a part of the older astronomy, and consequently was suspected of indifference to the numerical accuracy which entered into the faith of many astronomers; but we owe to him the reduction of spectra to measurement, and he never ceased striving after numerical accuracy in photometry, both visual and photographic. Without him we should not have had the splendid work now being produced—Miss Cannon's catalogue of the spectra and magnitudes and colour indices of 200,000 stars. There is fortunately not the slightest risk of obscuring her lion's share in the work by remarking that it could never have been originated but for Pickering: nor in recalling that he paid for the printing of the first volume himself is there any fear of forgetting that this was by no means the whole, nor the most important part, of his con-

tribution. To estimate the importance of his initiative, we must go back to the beginning of his work—in Miss Cannon's words, "to the eve of the greatest revolution this ancient science (of astronomy) had known since the days when Galileo constructed his rude telescope" (*Pop. Ast.*, Mar. 1919). It was a revolution foreseen by G. P. Bond from afar, for he wrote in the observatory Notebook of 1857, April 30: "Any considerable improvement in the sensitiveness of the present photographic processes will revolutionise practical astronomy—such an improvement as will enable us to take stars of the tenth magnitude in a second or two." Bond had himself made the first photograph of a star (α Lyræ at Harvard on 1850 July 17), and had noted the improvement in processes and instruments which had already taken place. But it was not till nearly two more decades had elapsed that the dry-plate brought the improvement he anticipated, and in the meantime the photographic method had languished. In 1882 Pickering, one of his successors, revivified the method at Harvard and played a leading part in the revolution Bond had foretold. In 1885 May he commenced his spectroscopic survey of the sky with a prism of 30° in front of a 2½-inch objective; and in 1886 he proposed to the American Academy to map the whole sky in a year. About this time Mrs. Draper founded at Harvard the Henry Draper Memorial, which gave the new work needful funds; the Boyden Fund of $230,000 enabled Pickering to establish the station at Arequipa in Peru, which at once gave him command of both hemispheres; and Miss Catherine W. Bruce of New York soon made a gift of a large telescope for the southern work. It was Pickering's energy which thus early made an effective start with the new weapon and enabled him to leave (again in Miss Cannon's words), "as his legacy to the world, the history of the sky for the last thirty-five years imprinted on the Harvard collection of photographs."

This revolutionary new departure might have turned the thoughts of some men away from the old visual methods, but Pickering was already absorbed in a great piece of personal observing. He had devised a photometer and himself observed with it for four hours on each fine night, though he had been threatened with pulmonary trouble and advised at that time that night air might cause him to go into a decline. Our ideas of "fresh-air treatment" have since changed, and Pickering claimed to have been one of the pioneers. His *Harvard Photometry* appeared in 1884 and was honoured by the award of our medal in 1886 (jointly with Professor Pritchard, who had worked on parallel lines). Later this developed into the *Revised Harvard Photometry*, and finally into the great work now appearing. But Pickering also showed his keen interest in visual work by organising observations of long-period variable stars. The full response is only now coming to reward him, but such co-operation as he managed to obtain was of the first importance for this department of work, and he laid the foundations of our present knowledge of many facts.

To return to the photographic work, for the commencement of which the date 1882 has been quoted above. One important provision for its future development was already in existence, though scarcely suspected at the time. The present writer has reason to believe that the happy inspiration was partly due to Mrs. Pickering.

"Mrs. Fleming began work at the Harvard Observatory in 1881. Her duties were at first of the simplest character, copying and ordinary computing. Later, as her powers developed, she was advanced until she occupied one of the most important positions in the Observatory."

[These words are Professor Pickering's own, but are requoted from *M.N.*, **72**, 262, to which further reference may be made.] Thus began woman's work at Harvard which has already left an indelible mark on the history of astronomy. Pickering was a devoted admirer of the Herschels, and it must have been a peculiar pleasure to him that this revival of the position taken by Caroline Herschel should have been twice honoured by this Society in the recognition of Mrs. Fleming and Miss Cannon. Besides these Harvard has provided several other workers of note, and the good example has spread elsewhere, though more tardily than it deserves.

It has been mentioned that Pickering was specially successful in gathering endowment for his beloved work, and his firm belief that it was on the whole economical to concentrate endowments rather than to scatter them was, of course, capable of misinterpretation. The suspicion of selfishness need not be slurred, for it can be met by at least two pieces of evidence. In the first place, he was himself a notable contributor to the Harvard funds, to which he was assiduous in calling the attention of others; and secondly, he is one of the very few who have interested himself in the needs of other astronomers. A gift of $6000 from Miss Catherine Bruce was carefully administered by him in grants to various workers in England, Germany, Norway, and Russia, as well as in the United States. He was much impressed with the new form of economy thus opened to him—he learnt of many cases where an already efficient organisation could be rendered doubly efficient by a small additional grant. In discussing this matter with the present writer and learning of the administration of our Government grant by the Royal Society and of the British Association grants, he urged that full details of these transactions should be published, as the best means of stimulating and developing such work. It is not his fault that this suggestion has not yet been acted upon.

It is only possible to give the briefest outline of the work done in a long and active life by such a man; but fortunately the full record is accessible in the *Harvard Annals* which he diligently published. A word or two may be added in conclusion on other matters. He was very fond of music, and it was one of his chief relaxations to hear Mrs. Pickering play. After her death he listened in the same way to a specially good gramophone, which

played a large selection of classical music. In his earlier days he was fond of long bicycle rides, and his love of mountain climbing led him to form the Appalachian Mountain Club, of which he was the first president. It now has over 2000 members. He liked a game of chess. On one occasion Simon Newcomb was imprisoned by bad weather on the Righi summit while Pickering was at the foot. Pickering telephoned to him proposing as distraction a game of chess, and asked whether Newcomb had a board for reference. Newcomb replied that he had not, but that the omission was immaterial, and so Pickering found: they played until the storm abated, but Pickering did not win a single game.

He was honoured by many Societies and took a keen interest in the general distribution of such honours. He received our Gold Medal twice, in 1886 and in 1901.

He was elected an Associate of the Society on 1881 June 10.

H. H. T.

Annibale Riccò, whose death on 1919 September 23 has deprived Italy of one of her foremost and most active workers, gained his early training in the University of his native city, Modena, in the Engineering School, the same school as that in which Tacchini was educated six years before him.

Riccò was born on 1844 September 15 at Modena. After taking his degree in mathematics and natural philosophy at Modena, he continued his studies at Milan and began life as an architect.

He was called to Modena, first as a teacher of geometry in the Technological Institute of that city, and later at the Agricultural Station for microscopical and meteorological observations. In these early years his work was concerned with economical subjects such as the temperature of wells, the calculation of the effect of heat on vegetation, and the spectroscopic study of the chlorophyll in plants.

In 1872 he undertook the duties of assistant in the observatory of Modena and of a teacher of geodesy; and in the following year he was appointed Professor of Physics in the Technological Institute of Modena. In 1877 he was called to a similar post in the Engineering School at Naples. Two years later, in 1879, he joined the staff of the Palermo Observatory and was made Professor of Technological Physics in the Engineering School of that city.

In 1890 observatories were established at Catania and on Mount Etna. In a note in *Ast. Nach.*, 126, 33, announcing the inauguration of these observatories in 1890 November, Riccò pays a warm tribute to the initiative and activity of Tacchini in the foundation of these important institutions. A Chair of Astrophysics was established in the University of Catania, and Riccò was called to fill the chair and to undertake the direction of the two observatories. The work to be done covered a very wide front of activity. Tacchini's initiative left its permanent impress. The Società degli Spettroscopisti Italiani had been founded under his inspiring influence in 1872; he had instigated the establishment

of an observatory on Monte Cimone (2160 m.) in 1880 and of the observatory on Mount Etna (2950 m.), and his long-continued residence at Palermo (1863-1879) had given him "un vivo affetto per la bella *Isola del Sole*," culminating in the establishment of the Catania Observatory. In succeeding Secchi as Director of the Osservatorio di Collegio Romano in 1879, Tacchini had been made also Director of the Central Office of Meteorology and also of a new department of geodynamics; and he had founded the Società Sismologica Italiana. And thus it came about that the Catania Observatory was charged with a vast province of work, including meteorology, terrestrial magnetism, seismology, and not only solar observations but also a share in the international undertaking inaugurated in 1887, the Astrographic Chart.

Riccò gave himself up to the huge task devolving upon him as director with persistent devotion for 29 years till the end of his life. The recording of solar prominences—a line of work in which the Italian observers have always rendered conspicuous service—was carried out on the lines inaugurated by Tacchini and systematised in the daily chart published in the *Memorie degli Spettroscopisti Italiani* from 1872 onwards and continued to the present day. Riccò joined Tacchini as co-editor of the *Memorie* in 1899, and since Tacchini's death in 1905 he had been sole editor. We have been able to count for years past on Riccò's regular notes in the *Memorie:* "Statistica delle macchie e facole solari osservate nel R. Osservatorio Catania," and "Statistica e distributione delle protuberanze solari;" and many other notes illustrating his studies of new relations. We may recall the words of Schwarzschild at the Bonn meeting of the Solar Union in 1913 (*Trans. I.U.S.R.*, p. 104), on the presentation of a communication by Riccò dealing with his homogeneous observations of 21,533 prominences observed in the course of 33 years; "Here in the prominences are indications of large periodic fluctuations as in the sun-spot activity. A result of this sort can only be attained by observations continued throughout a lifetime, as Professor Riccò has done."

As a further instance of the wideness of the scope of his activity, reference should be made to his researches on the terrible Messina earthquake of 1894. It was in 1896 that Riccò proposed to the Director of the Central Italian Bureau of Geodynamics to carry out a series of pendulum observations in Calabria, Sicily, and the adjacent islands. Tacchini approved the plan, and the work of the gravity survey was carried out by Riccò and Professor Venturi at 64 stations, Riccò making the determinations at 43 of them. A magnetic survey had been carried out by Professors Palazzo and Chistoni and others. Riccò summarised the work in his memoir (1907) of 10 pages and a map of Sicily representing the lines of equal anomaly of gravity: "Concludiamo dunque che in Calabria ed in Sicilia si ha coincidenza delle tre anomalie: della costituzione del suolo, della gravità, del magnetismo terrestre, e possiamo aggiungere pure la coincidenza di singolare sismicità."

Riccò took part in many eclipse expeditions: to Vyatka

(Russia) in 1887, to Menerville (Algeria) in 1900, to Torreblanca (Spain) in 1905, to Theodosia (Crimea) in 1914. In the 1914 eclipse Riccò was among those who discovered new lines in the red region of the spectrum of the corona; and he pointed out the relation of the principal line in the red group to Nicholson's coronal series.

In 1910 he was awarded the Royal Prize of the Accademia dei Lincei for his solar work; and his services were recognised by many other academies. At the meeting of the International Union for Solar Research at Meudon in 1907, Riccò was selected to be one of the three executive officers, and his selection was renewed in 1910 at Mount Wilson, and yet again in 1913 at Bonn. The meeting of the Union which, at his invitation, was to have taken place at Rome in 1916 was not held. At Brussels in 1919 July Riccò was elected as one of the four vice-presidents of the newly reorganised International Astronomical Union, and he invited the new union to hold its first meeting at Rome in 1922.

His quiet, unassuming devotion to the service of astronomy will only be fully recognised when the history of the work of the Catania Observatory is written. He was elected an Associate of the Society in 1910. H. F. N.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir F. W. Dyson, Astronomer Royal.*)

The year 1919 witnessed a gradual return towards normal activities. The observatory remains, however, somewhat understaffed, several vacancies caused by retirement not yet having been filled.

Transit-Circle.—During the year 5294 transits were observed, a large increase on the previous year. The sun was observed on 135 days and the moon on 106 days. Efforts are being made to overtake war arrears in the observations of the Backlund-Hough stars in the catalogue. The catalogue is well observed in parts, but several abnormally cloudy periods during the past autumn, and also previously, have left some poorly observed patches.

The mean corrections to the right ascension of the moon required by the *Nautical Almanac* and *Connaissance des Temps* remain practically identical with the corrections for 1916, 1917, and 1918. Some attention has been paid recently to the errors in the places of the planets Uranus and Neptune, with a view to finding evidence of a trans-Neptunian planet. The following are the errors (Tab. *minus* Obsd. R.A.) since 1910, as given by the Greenwich observations:—

	Error of Uranus.	Neptune.		Error of Uranus.	Neptune.
	s	s		s	s
1910	−0·19	+0·07	1915	−0·13	...
1911	− ·18	+ ·10	1916	− ·13	+0·13
1912	− ·12	+ ·09	1917	− ·10	+ ·14
1913	− ·22	+ ·07	1918	− ·13	+ ·13
1914	− ·16	+ ·09	1919	− ·12	+ ·18

The Catalogue of Stars for 1910 (Dec. +24° to +32°) is in the press. Part I. (Fundamental Stars) is complete, and the proof-sheets and revises of Part II. (Oxford Zone Stars) are complete to 18^h R.A.

Altazimuth.—Three observations of the moon were obtained in January and February. Since that date the instrument has remained out of use consequent upon the departure of the eclipse

observers early in March. The instrument is now being brought into use again.

Cookson Floating Telescope.—195 latitude plates and 3 scale plates were obtained during the year. The measurement of these plates is nearly completed.

Definitive values of the latitude variation at Greenwich to the end of 1918 and of the aberration constant given by the observations have been communicated to the Society. The detailed results of the seven years' observations, with a discussion of same, is ready for press.

Occultations.—Four disappearances were observed in February.

28-inch Refractor.—This instrument was in use from April 8 to August 15. 76 double stars have been observed, each on two or three nights. Practically all of these are pairs showing orbital motion. The observations of double stars made with this instrument since its erection are now being prepared for press. New orbits are being computed for all pairs showing sufficient orbital motion.

Since August the telescope has been out of use. It was found that the end bearings of the polar axis showed considerable wear; new pivots working in ball-bearings are, therefore, being fitted and also a ball-bearing end thrust. The progress of this work has been considerably delayed by the moulders' strike.

Thompson Equatorial.—25 photographs of the larger satellites of Jupiter were obtained on 16 nights between January 8 and March 24. These have been forwarded to Dr. de Sitter. At the end of March parallax observations were resumed, and 160 morning plates and 191 evening plates have since been obtained, each plate having three exposures on it. 5 photometry plates of Kapteyn selected areas were also obtained. In addition, Mr. Luyten took 20 plates of the variable RZ Cephei and 30 of the clusters M 11 and M 52.

With the 30-inch reflector 10 plates for position of comet 1919 *a*, Kopff, and 7 for position of comet 1919 *b*, Brorsen-Metcalf, were secured.

The measurement of the parallax plates was resumed after the measurement of the eclipse plates had been completed. 12 plates were measured up to the end of the year.

The Astrographic Equatorial.—The 13-inch object-glass was dismounted early in the year and taken to Brazil for observation of the solar eclipse. Parts of the driving mechanism being found considerably worn, the driving clock was dismantled in September and sent to the makers for overhauling. The instrument has, therefore, been out of use throughout the year.

The determination of proper motions of stars in Vol. III. of the Greenwich Astrographic Catalogue has been completed and is ready for press. The catalogue will contain the proper motion of nearly 13,000 stars between Dec. $+64^\circ$ and the Pole, together with the photographic magnitude and spectral type when the latter is available. All B.D. stars in zones 65° to 80° have been

examined by comparison of plates, and it is believed that all with centennial p.m. of 7″ or larger are included in this list; the photographic magnitudes of all these stars have been collected, the magnitudes of the fainter stars being determined from the measures of diameters in the Astrographic Catalogue supplemented by direct comparison on photometry plates.

Photoheliograph.—Photographs of the sun were obtained on 208 days, of which about 20 were days of poor definition. At the Cape Observatory photographs were obtained on 337 days, leaving for the year 8 days unrepresented by satisfactory photographs from the combined record of the two observatories; these, however, are represented in the daily series taken at Kodaikánal.

The complete series of photographs taken at the Cape from 1917 February to 1919 May have been received. From the Dehra Dûn series 43 negatives are being retained for examination or measurement.

The receipt of the Cape plates enabled progress to be made with the measurement of the negatives for 1917. By the end of the year the measurement had been carried to December 16, except for 9 days, for which plates are awaited from Kodaikánal. The measures up to 1917 April 9 have been fully reduced. The daily results for 1915 have been passed for press up to July 24.

From the preliminary reduction of the measurement of 36 photographs (representing the 5th, 15th, and 25th of each month), from each of the years 1917, 1918, and 1919, an approximate indication of the mean annual sun-spot activity during the present cycle can be given:—

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Mean daily spot-areas in millionths of sun's visible hemisphere.	7	152	697	724	1450	1100	900

Since 1919 August the sun-spot activity has steadily declined.

Wireless Time-Signals.—With a view to its use in longitude determinations with the aid of wireless telegraphy, the wireless equipment has been improved by the erection of a much longer aerial and the addition of a 5-valve and a 7-valve amplifier, together with a heterodyne for receiving continuous waves up to a wavelength of 17,000 metres. It is now possible to receive the 10^h signal from Darien (100 kilowatts) and the 17^h signal from Annapolis (350 kilowatts), both these signals being sufficiently audible for time comparisons to be made. Attempts are being continued to hear the signals from Pearl Harbour, Honolulu (350 kilowatts). In installing the new apparatus we are greatly indebted to the help given by Captain Slee of the Wireless Board of the Admiralty.

The Solar Eclipse.—The observers from the Royal Observatory, Messrs. Crommelin and Davidson, were absent from early in March until the end of August. On their return, the measurement of the photographs was at once proceeded with and was completed

by the middle of October. The results were communicated to a joint meeting of the Society and the Royal Society.

Printing.—The printing of the annual volumes of observations has been resumed and the greater part of the 1915 volume is now in press. In addition, as mentioned above, the Greenwich Catalogue of Stars for 1910 is in press, whilst the Zenith-Telescope Observations, the Double-Star Observations with the 28-inch, and the Catalogue of Proper Motions of the Stars in the Astrographic Catalogue are all ready for press.

Personal.—The observatory has lost during the year the services of Messrs. Maunder, Thackeray, Hollis, and Outhwaite, while Mr. Lewis left quite recently. They have been largely responsible for the success of the observatory in different branches for a generation, and their names are permanently associated with Greenwich. They carried back the traditions of the observatory to the time of Airy, and their retirement makes a break in the continuity of its history.

Royal Observatory, Cape of Good Hope.
(*Director, Mr. S. S. Hough, H.M. Astronomer.*)

Transit-Circles.—The observations of a list of stars selected from Boss's Preliminary General Catalogue were continued throughout the year. They comprise:—

Observations of Right Ascension:—	
Meridian transits	6293
Determinations of collimation by collimators	91
,, ,, level	290
,, ,, azimuth	174
Observations of meridian marks	708
Observations of Zenith Distance:—	
Determinations of Zenith Distances	6459
,, ,, runs	275
,, ,, nadir	259
,, ,, flexure	54

Heliometer.—Observations of the major planets at their oppositions have been continued, and the following have been secured:—

Opposition of Jupiter	14 obs. in distance	on 2 nights.
,, ,, Neptune	48 ,, ,, ,,	,, 6 ,,
,, ,, Saturn	12 ,, ,, ,,	,, 7 ,,
,, ,, ,,	12 ,, ,, position-angle	
,, ,, Uranus	30 ,, ,, distance	,, 5 ,,

Victoria Telescope and Astrophysical Laboratory.—The telescope and four-prism spectrograph with short camera have been in use on 151 nights for the photography of stellar spectra, 162 spectra being secured mainly for radial velocity determinations.

Long exposures (on three to five nights in each case) were given to Nova Aquilæ, η Argus, and the pair of stars C.P.D.-49° 11675 and 11676.

Two papers on "The Spectrum of η Argus" and "The Spectra of Nova Aquilæ No. 3, II., Transition to Nebular Spectrum" have been published in the *Monthly Notices* of the R.A.S. A third paper on the latter spectra of Nova Aquilæ is in course of preparation.

The Astrographic Telescope.—227 repetition "chart" plates for proper motion were taken by Mr. Wood of the Union Government Observatory during the months January–February and July–August. These plates are being compared with the corresponding original chart plates in the "blink" microscope of that observatory for the purpose of determining the p.m. of "quick"-moving stars relatively to the general background of slow-moving stars. In addition the following plates have been secured:—

South-pole region (for standard stellar magnitudes):		
	24 plates	with 284 exposures.
For the determination of a comparison magnitude scale:		
	4 plates	with 46 exposures.
Comet Skjellerup	2 ,,	,, 2 ,,
For adjustments	5 ,,	,, 9 ,,

Photoheliograph.—Daily photographs of the sun have been continued throughout the year. In all 693 negatives have been secured on 337 days.

The negatives up to 1919 May, accumulated during the war on account of transport restrictions, have been forwarded to the Royal Observatory, Greenwich.

Occultations.—Nineteen separate records of occultations of stars by the moon have been observed, viz.:—

Disappearances at dark limb . .	7
Reappearances ,, ,, ,, . .	12

Variable Stars.—The 6-inch and 7-inch equatorials were placed at the disposal of Messrs. Long and Skjellerup for observations of southern variable stars.

Some 116 stars have been under observation, and 1154 determinations of visual magnitudes have been secured.

Current Reductions.—All meridian observations up to 1919 December 1 have been reduced so as to exhibit apparent places. The reductions to mean place 1920 have been computed to 1918 November 5.

The MS. of ledgers of meridian observations 1912–17 is now being printed, and a catalogue of 1846 stars based on observations during 1912–16 has been sent to press.

The transformation of rectangular co-ordinates of the stars

contained in the Cape Astrographic Zones brighter than ninth magnitude (C.P.D.) into right ascensions and declinations has been completed. Considerable progress has been made in the formation of copy for press.

Arrangements have now been made with H.M. Stationery Office to resume the printing of the Cape Astrographic Zones. Proof-sheets for the zone $-45°$ Decl. have been received up to 6 hours R.A.

The reduction of the heliometer observations of the major planets during 1911–19 will soon be sufficiently advanced for the calculation of tabular distances and position-angles.

Two papers—(1) "Statistical Investigation of the Distribution of Stars and their Luminosities," and (2) "On the Maxwellian Law and the Motions of Stars"—have been sent to the Royal Astronomical Society for publication in the *Monthly Notices.*

Miscellaneous.—The time-signal service, meteorological observations, and seismograph records have been maintained as in previous years.

Royal Observatory, Edinburgh.
(*Director, Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland.*)

The year has seen the gradual return of the observatory to more normal conditions. In the month of May Mr. J. Storey and Mr. R. W. Wrigley were released from service with the Admiralty and resumed their duties. Since that date observations temporarily discontinued have been reopened and progress has been made in overtaking arrears in reductions.

In connection with the transit-circle, time studies have been continued upon the same lines as hitherto. The Fuess chronograph has been to a large degree reconstructed so as to put the three pricking levers upon independent axes and separate the magnet coils from one another as far as possible. The remodelled instrument shows satisfactory results.

With the 15-inch equatorial Mr. Storey has resumed measures of double stars upon the programme heretofore followed.

In the course of the year a grant was made by the Carnegie Trust for the Universities of Scotland which permitted the provision of a new mirror for the 24-inch reflector. The old mirror was a failure from the beginning, and recent examination of it confirmed exactly the defects specified in a letter of Mr. Cooper Key in 1875. Construction of a new mirror was entrusted to Mr. Calver, who further undertook to refigure the old mirror, in case there should be difficulty in procuring a new disc—a choice to be made ultimately between the old disc refigured and the new one. The former has now been received and has been subjected to careful measurement by zones, in which Rev. C. D. P. Davies kindly took part. It proves a fine piece of work, very smooth,

with a slight but negligible under-correction. Mr. Calver has also made a new flat, which, again, is a beautiful example, the curvature being quite insensible when it is examined under the transit-circle. It is intended to devote the reflector to photometric work, with the photo-electric cell and by other methods. Some structural alterations will be required in the mounting before it can be a convenient and satisfactory instrument, but it is hoped these may not prevent its early use, now that the mirror has at length been settled.

The preparation of photo-electric cells has been continued ; so far only potassium cells are ready, but salts of rubidium and cæsium have been procured, and it is proposed to use these metals also in future cells. A design for an electrometer with cell-holder, suitable for the telescope, has been prepared, but great delays are experienced in any work that cannot be done in the observatory. Meanwhile the old electrometer has been improved and fitted up for photometry. Through the kindness of Dr. Beatty, Mr. Baker paid a visit to Belfast University in August last, in which much information was gained.

Computations of the plate constants of the zones of the Astrographic Catalogue taken at Perth, Western Australia, has been resumed. The revision of the magnitude determinations mentioned in the last report has been hindered by the deterioration of the photographic images of comparison stars on the eye-piece scale.

Since May, continuous observations have been secured with the water-dropping electrograph for recording atmospheric potential.

Meteorological observations have been made as heretofore. The Dines float-barograph constructed in the observatory workshop has proved very satisfactory in operation.

Deep rock thermometers have been under observation for a long series of years at the Calton Hill. It was proposed to replace these by cutting a bore-hole in the Blackford Hill within the observatory grounds. But the rock proved so refractory and progress so slow and costly that the attempt has for the present been abandoned.

In June the Milne seismograph was replaced by a Milne-Shaw instrument, kindly lent by Mr. J. J. Shaw on the termination of its period of use at Eskdalemuir Observatory. When the weather is still the traces are very fine, but, unfortunately, the instrument is found to be highly sensitive to disturbance by wind, probably communicated as ground tremors, and many records are undecipherable in consequence.

During the past year the preparation for press of the manuscript of the *Theory of the Four Great Satellites of Jupiter* has been completed.

Cambridge Observatory.
(*Director, Professor A. S. Eddington.*)

The reduction of the meridian observations for the Cambridge Zodiacal Catalogue, comprising the work of the years 1900–1918, has been continued. All the star-corrections have now been computed, and the mean places formed. The reduction to 1900·0 has nearly been completed for the right ascensions. Vol. xxv. of the *Cambridge Observations* was distributed during the year.

The Sheepshanks equatorial has been used with a coarse diffraction grating for studying the change of effective wave-length with phase during the light-oscillations of Cepheid variables. Large numbers of exposures on δ Cephei and a comparison star were made on 19 nights; a few plates of ζ Geminorum and RT Aurigæ were also taken. The work, however, is still in an experimental stage, and there appear to be some discordances whose cause has not yet been traced. During September the mirror was resilvered, and the driving clock and electrical control completely overhauled.

The Director was absent from March 7 to July 14 on an expedition to observe the total eclipse of the sun on May 29 in the Isle of Principe, in company with Mr. Cottingham. The astrographic object-glass was kindly lent by the Oxford University Observatory, and the equipment fitted up at Greenwich. The Cambridge measuring-machine was taken out; and the measurement of the plates was made partly at Principe and partly at Cambridge after the return. Sixteen plates were secured during totality; but the majority of these showed no star-images owing to cloud. Two plates taken near the end of totality each showed five stars, suitable for the determination of the gravitational deflection of light; they were compared with four comparison plates, taken with the same instrument at Oxford, and gave a mean result for the deflection equal to 1″·61 at the sun's limb, Einstein's theoretical value being 1″·74. The accidental error was sufficiently small to rule out fairly decisively the suggested "half-deflection." A comparison of five plates of a check-field taken at Principe with five Oxford plates provided a check against systematic error, as well as a determination of the difference of scale at the two places, which was needed for the reductions.

A number of enlarged transparencies, lantern slides, and stereoscopic transparencies have been made, showing the great prominence which appeared on the eclipse photographs. The stereoscopic views show a considerable lateral motion in one of the arches of the prominence in an interval of two minutes.

Saturday evening exhibitions of celestial objects with the Northumberland telescope have been given as usual; but the weather has been particularly unfavourable. A course of demonstrations in practical astronomy is being given by Mr. Smart, and is attended by seven students.

Mr. W. M. Smart, M.A., was appointed Chief Assistant, and took up his duties in September.

Solar Physics Observatory, Cambridge University.
(Director, Professor H. F. Newall, F.R.S.)

Spectroheliograph.—Photographs of the sun's disc in K_{2-3} light have been obtained on 86 days (previous year, 126), and photographs of the prominences at the limb on 75 days (previous year, 120).

The general activity of the sun has continued to decline, and the outbursts of spots have been smaller than during last year. There have been several large prominences; the most notable was that photographed on the day of the total solar eclipse on 1919 May 29. A series of photographs was obtained showing remarkable changes, and an illustrated account by Mr. Moss was communicated to the Society (*M.N.*, 79, 553).

For the year 1918 October 1–1919 September 30, the Director of the Kodaikánal Observatory has sent 327 spectroheliograms showing the solar disc in K_{2-3} light. Of the 38 days missed in the Kodaikánal record during this interval, the Cambridge record has photographs for 10 days.

Much progress has been made in overtaking the arrears in photographic enlargements of the spectroheliograms received during the war; no less than 800 have been made in the past 12 months.

The examination of the Kodaikánal photographs in search of evidence of systematic distribution of the calcium flocculi has been continued. The orientation of the images, on which, since they are taken with a Foucault heliostat, the fiducial directions are a function of the time of observation, is now provided for by special appliances which have been fitted to the smaller heliomicrometer of De la Rue. In this manner each photograph to be examined is marked with the direction of the diurnal motion and the solar axis. The appliances have been found very convenient. The work is in the charge of Mr. Butler.

Photoheliograms.—Daily photographs taken with the photoheliograph at Dehra Dûn have been received, and the negatives are stored at the Science Museum, South Kensington. Positive prints have also been received from Dehra Dûn; some of them were received in bad condition, having been damaged by reason of fire on board ship.

Study of Sun-spot Records.—The study of the areas and life-history of single sun-spots from the Greenwich records 1889–1901 has been continued by Mr. Moss. The data are ready for final discussion and preparation for press.

The frequency of occurrence of outbursts of groups of sun-spots in different solar latitudes has been reduced to tabular form by the Director, with the assistance of his private secretary, Mrs. Beech. The graphical representation of the frequency for the three 11-year cycles 1879–1913 affords suggestive evidence of new relations. The irregular proper motions of spots in solar longitude and latitude is being studied in connection with Dr. Hale's work

on vortical motion. The required data relating to the cycle 1890–1901 are nearly completed.

Similar work relating to the cycle 1902–1913 has been started by Mr. Moss on lines indicated by the work done in relation to the preceding cycle.

Stellar Spectra.—The discussion of the spectrograms of Nova Geminorum II., secured in 1912 at Cambridge and at Allegheny, has been completed by Mr. Stratton and has been prepared by him for press. It is a large bit of work, which was begun before the war, and was taken up again by him on his return from military service to the observatory in the middle of 1919 February. A note by Mr. Stratton on the discovery of a displacement of the absorption lines which are characteristic of the spectra of stars of B type was communicated to the Society (*M.N.*, 79, 366), and a preliminary statement of the final results of his work on Nova Geminorum II. was communicated to the British Association at Bournemouth 1919 September.

The spectrograms of Nova Persei I., secured at Cambridge in 1901, have been measured by Mr. Stratton and the Director, and a paper on the results is approaching completion for the press.

The wave-lengths of bright lines recorded in the complex region between λ4600 and λ4650 in various celestial spectra have been tabulated by Mr. Baxandall. The different wave-lengths recorded appear at first sight to involve 30 or 40 separate lines, but it is found probable that not more than 6 or 7 lines are really implicated.

Positive copies on glass of an excellent series of spectrograms of Nova Aquilæ III. have been kindly sent to the observatory by Dr. Plaskett, the Director of the Dominion Observatory, Victoria, B.C. They are being measured and studied by Mr. Baxandall. The records missed on many days in the series of photographs obtained at Cambridge are in large measure supplied by the Victoria series.

A note by Mr. Baxandall on "Apparent Changes in the Spectrum of η Carinæ (η Argûs)," calling attention to differences between the published photographs of this spectrum by Sir David Gill in 1899 and by Moore and Sanford in 1913, was sent in MS. to H.M. Astronomer at the Cape Observatory, and has since been communicated to the Society (*M.N.*, 79, 619). Dr. Lunt was able to secure at the Cape Observatory two photographs of the spectrum with long exposures (9 and 8·8 hours) with interesting and important results.

A short note by Mr. Baxandall on "The Probable Origin of a pair of lines of peculiar behaviour in the Spectra of Nova Aquilæ III." was communicated to the Astronomical Society of the Pacific (vol. 31, 297). The lines in question are assigned by him as probably identical with two nitrogen lines which are abnormal, under certain modes of excitation, as compared with other nitrogen lines.

In a note on "Variations in the Ultra-Violet Spectrum of Nova

Aquilæ III." (*M.N.*, 79, 498), Mr. Butler called attention to changes detected by him in the earliest photographs secured by the Yerkes observers on the first three nights of the outburst of the Nova.

Investigations in Atmospheric Electricity.—The discussion of the data secured by Mr. C. T. R. Wilson has been continued. Several points that demanded further scrutiny have been elucidated. Publication of the results of his important investigations has been delayed in consequence of the need for further study of the subject.

Staff.—Mr. Stratton returned to work at the observatory in the middle of 1919 February, after four and a half years' military service on the Western war-front. At 1919 Michaelmas he resigned the office of Assistant Director, but continues research work on stellar spectra at the observatory.

Mr. W. E. Rolston is still absent.

Dunsink Observatory. (*Director, Professor H. C. Plummer, Royal Astronomer of Ireland.*)

The improvement in the general state of the sky, which was noted in 1918, has unfortunately not been maintained, and during 1919 a new low record of 43 tolerably fine nights has been established. Naturally the work of observation has suffered in proportion. A total of 133 plates was obtained with the Roberts reflector, while 101 plates were measured. Magnitude curves of Y Lacertæ and SW Andromedæ have been determined, and the results have been communicated to the Society. The harmonic analysis of the magnitude curves of variables in clusters has been extended to Professor Bailey's work on M15, and the complete results for 337 stars have been published. The observation of variable stars will be continued.

The time-service to Dublin has been continued as in previous years, clock error being determined with the meridian circle on 101 nights. Courses of lectures were given by the Director in Trinity College, Dublin, in Hilary and the summer terms. There has been no change in the staff.

Glasgow Observatory.
(*Director, Professor L. Becker; Assistant, James Connell.*)

The Director has been on leave of absence throughout the year, and the usual routine work connected with the time-service and meteorological observations has been carried on by the assistant.

For the first three months of the year the assistant had under his care a number of chronometers and watches belonging to the Admiralty, and carried on the work of an Admiralty Chronometer Depot.

The astrophotographic lens belonging to the large spectroscope was not returned from loan by the War Office until about the end of December. It is expected that it will be remounted in position early in the year.

Hill Observatory, Salcombe Regis, Sidmouth.
(Director, Sir Norman Lockyer, K.C.B., F.R.S.)

Since the date of the last report the observatory has been re-opened, Mr. E. L. Edwards, the newly appointed assistant, having taken up his duties on May 13.

The routine work of the Rusthall telescope, namely, the photography of the spectra of stars selected according to Sir Norman Lockyer's scheme of increasing and decreasing temperatures, has been continued, embracing stars of magnitude 5·00 to 5·25 down to 15° of south declination. The instrument has been in continual use since May 13, Mr. Edwards working it every fine night. After Major Lockyer's return to the observatory on September 4, on demobilisation, he and Mr. Edwards worked the instrument on alternate nights.

Apart from focussing plates and duplicates, seventy-two successful negatives have been secured. Many of the plates record the spectra of more than one star which are available for classification.

All the instruments are in good working order, having been well looked after by the attendant, Mr. Lake, while the observatory was closed.

The wireless installation has been again re-erected by permission of the Postmaster-General, and is in good working order, the Eiffel Tower time signals being utilised daily.

A daylight enlarging room has now been completed and is available for use.

The library has been considerably increased by gifts from the Director, Lieut.-Colonel F. K. McClean, and various institutions, of many transactions, books, and pamphlets.

The general meeting of the Hill Observatory Corporation took place on 1919 June 24.

Liverpool Observatory, Bidston.
(Director, Mr. W. E. Plummer.)

After the disorganisation due to the war, it would seem almost as difficult to restart the observatory on the old lines as to begin afresh. But some progress has been made. The wireless telegraphic apparatus has been remounted and communication with Paris is renewed. The long interrupted inquiry into a possible improvement of the longitude has been renewed. Extra meridional observations have been recommenced, particularly of comets, and

the renewed telegraphic communications from Brussels are much appreciated.

The inauguration of the Tidal Institute at the Liverpool University, with which the observatory is in active co-operation, will change the nature of the inquiries but not suspend the investigations that have been prosecuted for some time.

Owing to difficulties connected with labour and printing during the war, the Annual Report has not been published since 1917, but it is hoped that the issue will be resumed.

All routine work is continued as hitherto.

Radcliffe Observatory, Oxford.
(*Director, Dr. Rambaut, F.R.S., Radcliffe Observer.*)

At the opening of this year the staff of the Radcliffe Observatory was reduced to its lowest ebb. Of my former assistants only Mr. Robinson remained after the retirement of Mr. Wickham, which took place in the latter half of the previous year.

Mr. E. E. Bond, a youth of sixteen years of age, who was appointed early in the year 1918, gave what assistance he could, but the routine duties and reductions of the meteorological department occupied all his time and a very large part of Mr. Robinson's.

Mr. H. G. S. Barrett was demobilised about the middle of February, and returned to observatory duties on March 5, and Mr. J. G. Balk, after nearly five years' absence on military service, returned on August 18. Mr. Bond, who had performed very useful work at the observatory for one year and nine months, resigned on October 25.

Mr. Wickham's post has not yet been filled up.

In the earlier part of the year no stellar photography was attempted. In August the slight injury to the breech-piece of the 18-inch guider (mentioned in the report for 1918) was repaired by Messrs. Troughton & Simms, and, after a thorough overhauling and recleaning of the telescope, the second stage of the work on "Selected Areas" was commenced in September. Between that and the end of the year fifteen photographs were secured, five on Kapteyn's original plan, eight control plates, and two focus plates. Of the control plates three are slightly defective or imperfect, owing to broken weather or other causes, and will have to be repeated when an opportunity occurs.

The five plates taken on Kapteyn's plan prove very satisfactory, and appear to have been very little impaired by their ten years' sleep. So far as we have gone they do not seem to have diminished in the least in sensitiveness. As might be expected, they are slightly darkened, especially near the edges, but the quality of the images is good, and the arrangement of the four exposures is all that could be desired. For the control plates some experiments have been made in photographing through the glass for

comparison with those obtained (and developed immediately after exposure) some ten years ago.

In October and December visual observations were made with the 18-inch refractor for altitude and azimuth adjustment of the polar axis on which this and the 24-inch are mounted. The adjustment remains very satisfactory, the resulting corrections being: in altitude $+5''\cdot2$, and in azimuth $+1''\cdot3$.

In May the breech-piece of the Transit-Circle was sent to Messrs. Troughton & Simms for the insertion of a new system of wires, and the equatorial intervals of the whole system of 17 new wires were subsequently determined from transit observations.

With the "Barclay" equatorial the bright marking on Jupiter, discovered by Mr. Sargent, and described by him in *M.N.*, **79**, 218, was observed on January 24 and 26, and the Solar eclipse of November 22 (first contact) was observed with it and the Marlborough telescope. It has also been employed on several "Open Nights" by visitors to the observatory.

Three very old wooden telescope-tubes and a "nocturnal," the property of the Radcliffe Trustees, were lent for the Exhibition of Early Scientific Instruments, which took place at the Bodleian Library in May.

Volume liii., part iii., of the *Radcliffe Observations*, containing the results of meteorological observations made during the year 1918, was printed, and a limited number of copies distributed in the usual manner.

University Observatory, Oxford.
(Director, Professor H. H. Turner, F.R.S.)

Vol. iv. (zone $+61°$) of the Vatican portion of the Astrographic Catalogue was completed during the year, and some copies have already been received. The reductions of zone $+57°$ are complete, and for $+56°$ equations have been solved to $18^h\ 0^m$. We are thus on the point of commencing the last zone ($+55°$) of the Vatican share. Ledgers have been formed from $+64°$ to $+59°$ by Miss Bellamy, who incidentally keeps watch for large proper motions; thus two curiously opposed P.M.s were reported to the Society in June last.

The Santiago ($-22°$) work has been almost stopped owing to the poor quality of the plates supplied from Santiago, the great majority of them not being worth measuring. It is hoped that better plates will shortly be received in response to urgent representations made, and Mr. Hough has also kindly promised to take such plates in this zone as he conveniently can for measurement here. Further, the Nizam of Hyderabad has kindly instructed his Observatory to photograph and measure this zone according to the suggestion of duplication made in *M.N.*, **79**, 571, as a check on possible systematic differences in stellar images on plates taken in the northern and southern hemispheres.

In preparation for the Eclipse Expeditions of May last Mr. Bellamy took a large number of trial and test photographs with the Astrographic Equatorial, cutting down the aperture by various diaphragms suggested by the eclipse observers. The object-glass was dismounted on February 10 and taken by Professor Eddington and Mr. Cottingham to Principe. It was safely returned on July 31, but could not be remounted until the much later return of some accessories. The instrument was thus out of action for the greater part of the year, and has only just been put again in commission. But before it was dismantled the Rev. F. H. Macklin, research student, took a long exposure photograph of the h and χ Persei clusters, which has afforded much material for study.

The meteorological reductions have been temporarily suspended, preference being given to an investigation of Chinese earthquakes, which led to the better identification of the 15-month period, and to the suggestion of longer periods of 79 and 240 years. The former is possibly related to the meteorological period of 40 years, the latter to the long-period term in the moon's motion. To elucidate this latter possibility Dr. Fotheringham (temporarily attached to the staff of the Observatory) undertook a thorough investigation of the long-period term from modern observations, and he finds that when the observations of the last ten years are included with those formerly discussed by Brown, Cowell, and Newcomb, the value 240 years for the long-period gives a secular acceleration quite reasonably in accord with that found from old observations, though 250 years would be better. His paper appeared in the *Monthly Notices* for 1920 January.

The seismological work has now been transferred from Shide to Oxford owing to the departure of Mrs. Milne to Japan in September last and the consequent sale of the house and observatory. At present the arrangements for housing the library and documents are purely provisional, but the liberality of Dr. Crombie of Aberdeen has made it possible to secure a small house in Oxford (though not yet the occupation of it) which will meet present requirements. During the year the records for 1916 have been printed, with a good deal of revision and addition owing to the slow arrival of belated records. It will naturally take some time to recover from the effects of the war.

In discussing the classification of long-period variables the star W Cygni was noted as important because of its low galactic latitude and the character of its curve. Mr. C. L. Brook kindly sent for examination a large number of observations of this star made by the B.A.A. variable star section; and Miss Blagg undertook a laborious analysis of them, with very satisfactory results. The star was found to have two independent variations in 129·6 and 243 days respectively; and if some rather small quantities can be trusted as even roughly accurate, the latter variation is of Group II. type (Phillips) and is waning, while the former is of Group I. type and is waxing. Now, it had already been suggested that the stars in both

groups could be arranged in significant series according to the length of period, one element that follows the period being the range of variation which is largest for long-period stars of Group II. (500 days), diminishing throughout Group II. to the short periods (100–200 days) which are approximately equal in range to the short periods of Group I., and still further diminishing as we ascend Group I. to the long periods. It is now suggested that this sequence represents a possible life-history of these stars, *i.e.* that they begin life as long periods and large range in Group II.; they diminish range and shorten period to about 100–200 days; cross over to Group I. as apparently W Cygni is in the act of doing; then lengthen period (but continue to diminish range) in Group I. The examination of the most striking cases of change of period supports this view so far, and incidentally has thrown much light on the nature of the changes in period, which are apparently *liable* to occur at regular intervals (suggesting a recurrent cause), though a recurrence may pass without change. A new chapter, which promises at present some interesting reading, has thus been opened in the investigation of these stars.

The reduction of counts of the Astrographic zones has been continued, and two broad belts of several degrees in width give specially interesting results, but are not yet quite ready for press.

The Director attended the meeting of the International Research Council at Brussels during the summer, and was nominated to take charge of two Committees of the Astronomical Union—one on the Astrographic Chart and Catalogue, and the other on Lunar Nomenclature.

The Coats Observatory, Paisley.
(Principal M'Lean, B.Sc., C.E., Convener.)

The usual work of the observatory, astronomical, meteorological, and seismological, has been regularly carried on throughout the year. The visitors to the observatory numbered 394. Amongst these were members of the West of Scotland Branch of the British Astronomical Association, the Physical Society of Glasgow University, and other scientific bodies. Owing to the necessity for complete rest, the Rev. Charles A. Hall, F.R.M.S., has retired from the Convenership, and Principal M'Lean, B.Sc., C.E., has been appointed to the post.

Imperial College, South Kensington. (*Professor A. Fowler, F.R.S.*)

As in former years, the work of the observatory was mainly connected with the instruction of students, but the instruments were occasionally utilised for spectroscopic observations of sun-spots and prominences.

Experimental investigations were carried on in the spectroscopic laboratory, but most of the results are not yet ready for publication.

Mr. Curtis, who returned from military service in the early part of the year, completed a revision of the value of the Rydberg constant for spectral series (*Proc. Roy. Soc.*, A, **96**, 147), and made further studies of the band spectrum of helium. Mr. Curtis resigned in July in order to take up an appointment at the University of Sheffield. Mr. C. C. L. Gregory returned from military service in March, but his research work was interrupted by his appointment as assistant at the Helwan Observatory. Soon after his return from military service, Mr. D. L. Edwards, research student, was appointed assistant at the Hill Observatory, Sidmouth.

A vacuum spectrograph, having a concave grating of one metre radius, has been added to the equipment with the aid of a grant from the Government Grant Committee. In the first instance, this instrument will be used in a further attempt to discover the nature of the series which include the lines of silicon and carbon which appear in the spectra of the B stars.

Stonyhurst College Observatory.
(*Director, Rev. A. L. Cortie, S.J.*)

The death of Father Sidgreaves, the late Director of the observatory, on 1919 June 12 was a grievous blow to the work of the observatory. He had always kept the magnetic observations and reductions in his own hands. This routine work, which absorbs much time, has now to be taken up by the present Director.

Through the kindly intervention of the Council of the Society and of the Astronomer Royal, our wireless installation was restored to us by the Postmaster-General in June, and was re-erected in its original form by the local post-office engineers in September. The time-service is under the charge of Father J. Rowland, S.J., who joined the staff as chief assistant in October.

The meteorological and magnetic observations have been carried on as usual. The collimator magnet for absolute determination of H was damaged early in the year, and a new one had to be procured. Its constants have been determined at Kew by Dr. Chree.

The Milne seismograph has been out of order for some time. It is now working satisfactorily.

Observations of the solar surface were made on 220 days, and include 223 drawings on 218 days, and notes on uncompleted drawings on 2 other days. Of these drawings 174, on 171 days, show all spots and faculæ visible, and the remaining 49 are complete for all spots, but lack the full record of the faculæ. Particular attention has been devoted to the faithful and exact reproduction of the faculæ, and to showing how the flow of the faculæ connects the several spot outbursts.

The mean daily disc-area of the spots (in units of $\frac{1}{5000}$ of the visible surface) stands at 8·35. In 1918 it was 7·90, and in 1917, the year of maximum, 12·10. The sun-spot activity

which had steadily declined since 1917 August, and throughout 1918, revived in 1919. This is indicated not only by the mean daily disc-area of the spots, but also by the magnitude of individual spots.

The months of greatest activity were February, May, June, and August. The most remarkable and extensive outburst of the year was the triple equatorial group of August 13–25, which was central about August 19. This compound group extended 20° in longitude and 17° in latitude, and its appearance was heralded by the very violent magnetic storm of August 11–12. The two chief members of this group became regular in form early in their life-history (August 23–24), and lasted throughout 4 solar rotations, being last seen as a small single spot on the sun's west limb on December 7. This spot was the more northern one of the two principal members of the original group. After the first appearance of this fine group the measured spot-area showed a steady and continuous decrease until the end of the year.

In our report for 1917 it was stated that a comparison had been instituted between our drawings of solar faculæ and some spectroheliograms in K_2 and H_α radiations, furnished through the courtesy of the directors of the Mount Wilson and the Yerkes Observatories. A preliminary comparison of the drawings of the faculæ and the photographs of the flocculi showed an almost perfect agreement between the faculæ and the calcium flocculi, but no similarity with the hydrogen flocculi. A further comparison has been rendered possible, through the kindness of Professor Newall in furnishing spectroheliograms in calcium light $K_{1,2}$ for dates in May, June, and September, on which we had particularly good drawings of the faculæ. In every single case the general agreement of the faculæ and the flocculi, both in extent and in character, is most striking. It may be safely stated that no prominent calcium flocculus is shown on the photographs without a corresponding facula on the drawings. We are hoping to be able to follow up this subject, as also to chart the flow of the faculæ in certain areas of long-continued spot activity. A beginning has already been made with the group of spots that was on the sun's east limb on the day of the total solar eclipse, May 29. This disturbance lasted from April 6 to August 24. It has long been suspected that it is this flow of the faculæ, connecting several successive outbursts of sun-spots, increasing or decreasing in solar latitude, which is operative in causing the magnetic field in sun-spots. Such extended regions would each form a huge solar cyclone.

For the reasons already stated, not much work has been possible with our solar and stellar spectrographs. But photographs of the spectrum of Nova Aquilæ were secured in August, and the results of the measures have been communicated to the Society.

Several lectures on astronomical topics have been given by the Director in military hospitals and camps.

Mr. A. A. Buss's Observatory, Chorlton-cum-Hardy.

Solar observations were carried on during 1919 almost exclusively with the 6-inch Simms O.G. in conjunction with the Rowland grating spectroscope.

The Sun was observed on 150 days; frequently three observations were made in the day—one early, one about midday, and one in the evening shortly after 6 p.m. Although the period of maximum activity has probably passed, there has been during the spring and summer of 1919 a remarkable secondary activity-wave, and a number of magnificent naked-eye spots and groups were seen, also some exceptional disc and limb eruptions observed spectroscopically.

The frequent presence of enormous dark H_a flocculi seen projected on the disc has been a marked feature again, and in several instances it was possible, in cases where these absorption markings were near enough to the limb, to see their continuation outwards and above the chromosphere as dull or fairly bright prominences. Again in many instances D3 has been seen in absorption over active areas, with or without spots, sometimes over areas of faculæ only. Also claw-shaped markings were seen in H^a light, and again the strange appearance of H_a near some active areas, showing deflection towards the red, along a great length, sharply terminating in coincidence with the line at wavelength 6564·45 given by Rowland as an atmospheric line.

The transit of the fine spot-group in North Latitude, visible from May 12–26, afforded a quite exceptional instance of eruptive activity on the 13th, which culminated in a maximum about 5.25 G.M.T. It was comparable with the celebrated outbreak observed by Carrington and Hodgson 1859 Sept. 1, but in the present case it was observed spectroscopically. The entire length of the spectrum appeared like several superposed white ribbons on account of the intensity of the outburst, all the ordinary dark chromospheric disc-lines being brilliantly reversed, from the red helium line far towards the violet. The Stonyhurst magnetic record shows plainly the growing intensity of this eruption, and also marks its climax as occurring at 5.25 G.M.T.

Another most remarkable feature of this eruption was the behaviour of a prominence which, on reaching the limb behind the active area, first showed deflection towards the red; it then bent abruptly towards the observer, and burst rocket-like into a great number of brilliant detached flecks, all of which appeared quite outside the position of the line, on its violet side. This seems to have been a similar phenomenon to that observed by Prof. Young on 1871 Sept. 7, but in that case it was seen unforeshortened; in the present case greatly foreshortened. Other almost equally intense displays of disc-eruptions were witnessed while the same spot-group was crossing the disc; also on other occasions during 1919, particularly from August 3 to 17, during

the passage of another spot-group. The display of prominences on May 27, 28, and 29 was particularly well observed, also that of July 15. General limb and prominence observations were made on practically all days when the Sun could be observed, a very fine eruptive prominence being seen in the S.E. quadrant so recently as Dec. 26 last; also some rather fine isolated spots during the last few months of the year, but general activity has decidedly dropped compared with what it was during spring and summer.

Mr. C. F. Butterworth's Observatory, Waterloo, Poynton, Cheshire.

The working conditions were equal to the average of the past ten years. Work was possible on 232 nights, on 171 a full night's work was done, and over 100 were first class throughout the dark hours. First place is given to visual estimates of long-period variable stars, for the British Astronomical Association, with the 6-inch Grubb refractor. Three irregular and 32 long-period stars for the V.S.S. and 28 "extra" stars provided 3700 results, which were sent to the Director.

For survey of variation in the coarser features of bright-line stars, a 6½-inch 21° prismatic camera is used, strapped to the same refractor. With this photographs of the spectra of *o* Ceti, P Cygni, *α* Orionis, and *γ* Cassiopeiæ have been taken on all possible nights, together with suitable comparison stars. Fourfold enlarged prints of all have been made, giving a scale of 50 mm. from H*α* to H*γ*, the same as used for the spectrum of Nova Aquilæ III. Panchromatic plates alone are used.

The usual meteorological observations are recorded.

Wolsingham Observatory. (*Rev. T. E. Espin.*)

The search for new double stars in the selected zones has been continued with the 24-inch and 17¼-inch during the past year, and the results have been communicated to the Society. In addition, determinations of the magnitudes of 129 red stars have been made by Mr. Milburn, in 710 observations, and of 77 stars by Rev. T. E. Espin, in 332 observations. The variable star B.D. + 39°, 3476, R.A. $18^h\ 34^m{\cdot}8$, N. Decl. 39° 35′ (1900) has been observed on 108 nights. The star passed a bright maximum in the early part of August, reaching magnitude 5·9. Another maximum occurred in the middle of November. The period is apparently irregular.

Mr. A. M. Newbegin's Observatory, Wallington, Surrey.

The usual work on the solar prominences was continued to the end of May, when the instrument was dismounted and moved to

Sutton. The opportunity was taken to send the tube to T. Cooke & Sons of York to have an iris diaphragm fitted to the O.G., and a new position circle to the spectroscope.

Owing to a serious fracture in the tube it was decided to make a new one in steel. The completion of this work has been prevented by the disastrous strike in the ironfounders' trade, and observations are at a standstill.

Rousdon Observatory, Devon.
(*Sir Wilfrid Peek; Mr. C. Grover, Observer in Charge.*)

The observatory is maintained in its usual good order. Weather has been very changeable; September and October were the best observing months. Observations were made on 149 nights. Observations of the long-period variable stars with the $6\frac{4}{10}$ equatorial were continued on the same lines as in former years, and 424 magnitudes were recorded, making a total of 14,563 magnitudes during the thirty-four years this work has been in progress: 517 maxima and 560 minima have been observed. Nova Aquilæ was observed from June to December. During July, August, and September the light varied little from 7·7 magnitude, but during May, October, and November the light ranged from 8·2 to 9·1 magnitude and was very irregular. During June the colour was pale white, but when it brightened it changed to a clear blue, and was always sharply defined.

Towards the end of the year the luminosity of the midnight sky was sometimes very striking; the early evening hours were often intensely dark, but towards midnight a soft glow suffused the sky, and the distant landscape was sometimes so distinct as to suggest faint moonlight when the moon was quite absent.

The usual meteorological observations are regularly continued.

The Rev. T. E. R. Phillips's Observatory, Headley, Epsom, Surrey.

The usual observing programme of recent years was again carried out.

A number of double stars, some of them close pairs, were measured with the Coleman equatorial belonging to the Society, and systematic observations of the planets were obtained with this and the reflecting telescopes. An account of some recent extensive changes in the surface features of Jupiter, including the fading out of the great "S. Tropical Disturbance" and the disappearance of the "Red Spot Hollow," has been communicated to the Society.

An unsuccessful attempt was made to observe the passage of Iapetus through the gap in the shadow of Saturn's rings caused by the Cassini division on February 28. Clouds were troublesome,

and the atmosphere was so thick and murky that Iapetus could not be detected even in the 18″ reflector.

The close approach of Neptune to the star B.D. + 18°, 2016 on May 12 was observed under fairly good conditions, and a number of micrometer measures of position-angle and distance secured at intervals of a few minutes. The results obtained have been discussed by Mr. S. B. Gaythorpe (*B.A.A.J.*, 29, 222).

Several observations have been made of the physical appearance of Nova Aquilæ III. The star was very distinctly green, the greater part of its light being concentrated in the nebular radiation λ5007, though indications of fainter lines and a feeble continuous spectrum were also observed.

In general aspect the Nova frequently seemed not quite like a star. On July 9 a slight elongation was suspected in PA 125–305, and on several occasions it did not appear to come sharply to focus. At the last observation, on November 21, it somewhat resembled Uranus or Neptune, though it was less well defined.

Taking the year as a whole, the seeing conditions were very poor. There was quite an unusual amount of clear sky during the autumn, but definition was seldom really good, and the number of first-class nights well below the average.

The meteorological observations were continued.

Mr. Reynolds' Observatory, Harborne, near Birmingham.

During the year systematic work has been undertaken in the photography of nebulæ with filters transmitting definite ranges of the spectrum. The principal objects dealt with in this way were the Orion Nebula and the Dumb-bell Nebula, the results obtained being the subject of two papers communicated to the Society. Besides the gaseous nebulæ a beginning has been made with the brighter spiral nebulæ to determine the comparative distribution of the red, green, blue, and ultra violet light in this class; and some promising results were also obtained in the photography of bright open clusters with an orange screen and red-sensitive plates for the detection of red stars.

The same method was applied to the photography of Jupiter to settle the question whether the contrast between the belts and zones increased or diminished in passing from the blue to the ultra violet. A series of images in both ranges of spectrum were obtained on the same plate, and it was conclusively shown that the contrast was increased in the ultra violet compared with the blue. Some well-defined unscreened photographs of Jupiter were secured with the Cassegrain focus and an enlarging lens. As the 30-inch Common mirror which formed part of the original equipment of the Helwân Observatory has been replaced by the Ritchey mirror, it has been arranged to mount the former at Harborne instead of the present 28-inch.

Mr. Harold Thomson's Observatory, Newcastle-on-Tyne.

The work of previous years on planets and variable stars has been continued.

Nova Aquilæ III. has been systematically observed during the year, special attention having been paid to the visual spectrum. When last seen in December the Nova was between seventh and eighth magnitude. The continuous spectrum has remained easily visible during the whole period of observation, but there appear to have been some fluctuations in its intensity relative to the bright lines, as was noted usually in the case of Nova Geminorum II.

The appearance of the disc of the Nova has been carefully studied on many occasions, but poor definition has frequently prevented satisfactory observations from being made. No sign of nebulosity has been observed surrounding the disc, which, however, has usually appeared in the 12½-inch reflector somewhat larger than those of neighbouring stars.

A few observations have been obtained of Nova Geminorum II., which is now about equal in brightness to a small star about 12″ from the Nova in P.A. = ± 17°·6, which is estimated at about 13·3 magnitude.

Comets 1919 *b* and 1919 *c* were observed, but presented no telescopic features of special interest, except that the bluish-green colour of 1919 *b* was very noticeable in the reflector.

The Dominion Observatory, Ottawa, Canada.
(Director, Otto Klotz.)

Meridian Work.—Observations with the meridian circle were obtained on 99 nights. The observations were, as heretofore, divided between the programme of latitude stars under observation and transit observations for determination of clock error and measurements of longitude.

The complete list of 3162 latitude stars, upon which observations have been carried on for some years, was issued in mimeograph form during the year. Observations have been confined mainly to the more poorly determined stars, with the object of furnishing a list having a maximum probable error of ″·25 for the present day.

Field observations for latitude and longitude were carried out at one station in eastern Quebec, the longitude being determined directly from Ottawa.

The time-service has been maintained as in previou syears. There are 9 secondary master-clocks synchronised continuously from the observatory; these in turn control 386 clocks and dials of various kinds, including two tower clocks. Time-signals are sent out by telegraph and telephone, and the time is recorded on the various seismographs at the observatory. A comparison is

made daily with Washington time by means of the wireless time-signals sent out by Arlington; a small systematic difference is in evidence.

Astrophysics.—During the year 1919 the 15-inch equatorial has been employed as formerly in the determination of the radial velocities of spectroscopic binary stars. The programme consisted mostly in the study of the early class B spectra, B 1 to B 5, with the object of discovering very short-period binaries as well as variations in the widths and intensities of spectral lines. About 50 have been measured and reduced. Altogether 18 plates were secured. The two Metcalf comets of 1919 were observed and followed during August and September.

Solar Physics.—The 24·5 m. cœlostat reflecting telescope and 7 m. grating spectrograph have been utilised as formerly in observing spectra of the sun—centre of disc, limbs, and points intermediate—along with standard iodine absorption spectra and arc spectra, 9 strips of spectra being photographed at each observation. In all about 900 observations were recorded photographically, covering the problems of solar rotation, convection, pressure, distance, and the still doubtful Einstein gravitational effect on the wave-lengths of solar spectrum lines. The year was abnormally hazy and cloudy, especially in May and June, when there were many forest fires in northern United States and western Canada.

To obtain the international standard electric arcs a 220-volt D.C. generator has been installed. Four 6-ampere arcs may be run simultaneously and their spectra recorded along with 5 strips of spectra from centre and limbs of the sun.

Seventy simultaneous observations of the rotation in north and south solar hemispheres in 1918 June and December, at λ 5600 and λ 5200, indicate a rate of rotation at 45° latitude north, 1·13 km. per sec., and south 1·19 km. per sec.—a result directly the reverse of that obtained by Hubrecht in the Cambridge observations of 1911 June.

Stellar Photographic Photometry.—The observing list comprises 10 stars, and 88 plates were obtained. A thermopile is being installed in connection with this work. Nova Aquilæ was observed till the middle of October.

Terrestrial Magnetism.—The magnetic survey of Canada was continued, but the work was confined to "repeat" stations for securing data for secular change in declination, inclination, and intensity. Sixty stations were occupied covering 33° in longitude from Winnipeg to the north-west Pacific coast at Prince Rupert.

Seismology.—The year has been remarkable as regards the limited number of severe earthquakes. Altogether 97 were recorded, but of these only 25 were sufficiently well marked to enable the distance to be computed. In 1918 there were 141 earthquakes recorded here. Monthly bulletins continue to be issued.

Publications.—During the year the observatory issued 23 publications for distribution.

The Dominion Astrophysical Observatory, Victoria, B.C.
(Director, J. S. Plaskett.)

This is the first report presented of the work of this institution, which began actual observing on 1918 May 7. Contracts for the telescope were awarded in 1913 October, the mounting was completely erected in 1916 October, but owing to unavoidable delays the mirror was not completed until 1918 April.

For the first year, until 1919 April, only the Director and one astronomer, Dr. R. K. Young, were available to carry on the work. Mr. W. E. Harper commenced duty in April and Mr. H. H. Plaskett in 1919 October. With this staff the work can be more adequately carried on than at first, although additional help is required.

The principal work of the 72-inch telescope has consisted in the determination of the radial velocities of a selected list of stars and other spectroscopic work, but direct photographs of nebulæ and clusters and of special regions for the determination of magnitudes have been made.

Considerable experimental work in determining the figure of the mirror by the Hartmann extra-focal method was performed, and the zonal aberrations under different temperature conditions determined. Under constant temperature, the maximum longitudinal aberration at the principal focus is about 0·25 mm. Under the changing temperature in the dome this is sometimes increased to 3 mm., showing the necessity for protecting the mirror against these temperature changes. An insulating covering around the lower section of the tube reduced the temperature change around the mirror to about one-third of that in the dome and the maximum aberration to about 1 mm., an excellent working figure.

In direct photography, after the insulation of the mirror, excellent photographs of nebulæ and clusters, the minimum diameter of star images being only slightly over one second of arc, were obtained. It was proposed to make photographs of the Harvard Standard Regions with an objective grating for photographic and photo-visual magnitude determinations of stars in these regions down to the twentieth magnitude. This work was arranged in co-operation with Professor E. C. Pickering, Director of Harvard College Observatory, who undertook to measure the plates, but his death has led to the postponement of the work after sufficient had been accomplished to show the suitability of the telescope and the feasibility of the method.

The spectroscopic work has mainly consisted of radial velocity determinations of stars from a list of about 800 selected from the Preliminary General Catalogue of Boss. This selection was made, in co-operation with Mt. Wilson, from those stars in the catalogue, north of the equator, for which velocities had not been obtained. The division of the unobserved stars between here and Mt. Wilson was so arranged that each would complete their proportion about the same time, leading to the determination of the radial velocities

of all Boss stars within reach at the two observatories in the minimum time.

The magnitude range is from about 5·0 to 8·0, with a few fainter, and, in view of the faintness of the major part of the stars, it was deemed advisable to use single-prism dispersion. Until 1919 August a prism, kindly lent by Professor Chant of the University of Toronto, giving a linear dispersion of about 35 A. per millimetre at Hγ, was used. A new Hilger prism was then substituted which gives 29 A. per millimetre. With a shorter focus camera, for stars fainter than 7·8 photographic magnitude, a linear dispersion of 49 A. at Hγ can be obtained.

From 1918 May 7 to 1919 December 31, 3443 star spectra were obtained, over 3000 of these being in pursuance of the regular programme and the remainder of miscellaneous objects. Notwithstanding the small staff, all but about 400 of these spectra are measured, and a number of the stars have their velocity completely determined. It is proposed to obtain a minimum of 6 spectra of each star, increasing to 8 or 10 if the lines are poor. As the probable error of measurement of spectra with good lines has been shown to be of the order of 1 kilometre per second, this will ensure that, in general, the probable error of determination of the velocity of a star will be less than half a kilometre.

In the course of these measures, 100 spectroscopic binaries have been discovered, and of these binaries Boss 4507, 4669, 5026 and H.R. 8170 have had the elements of their orbits determined. Two binaries discovered elsewhere, 1 Geminorum and ι Delphini, have also had their elements determined, and considerable additional work has been done on 12 Lacertæ. Numerous spectra of Nova Aquilæ No. 3 were obtained and measured and a preliminary discussion published, besides other minor spectroscopic investigations

The eclipsing variable TW Draconis, U Ophiuchi, and RS Vulpeculæ, for which the photometric elements had previously been obtained, were observed for radial velocity and their spectroscopic elements determined. In the last two both spectra are visible, and consequently the absolute dimensions, masses, and densities have been obtained.

The first eight numbers of vol. i. of the publications of the observatory, containing a description of the observatory and equipment and the spectroscopic orbits described above, are in press and will soon be issued.

Helwán Observatory, Ministry of Public Works, Egypt.
(*Director, Mr. H. Knox-Shaw.*)

Time-Service.—The time-service has been maintained as usual. Transits were taken on 60 nights. The Riefler clock stopped in January owing to corrosion of its winding contact, but afterwards went extremely well.

Reynolds Reflector.—The telescope was overhauled in November

and photographic work started in the second half of the month. It was used in all on 25 nights, and 25 plates were exposed in the reflector and 9 in the prismatic camera, the former mainly on nebulæ and the latter for test purposes.

General.—Mr. C. C. L. Gregory joined the staff in November as Chief Assistant. The Director is able at present to spend only a small part of his time on astronomical work.

The observations of solar radiation have been continued as in recent years, and there is now a considerable amount of material ready for discussion. The same meteorological, seismological, and magnetic observations were made as formerly.

Nizamiah Observatory, Hyderabad.
(*Mr. T. P. Bhaskaran, M.A., in charge.*)

The usual work of the observatory on the Hyderabad section of the Astrographic Catalogue has been carried on regularly during the year.

Seventy-eight catalogue plates containing 36,071 star-images have been secured and measured, which with those measured in previous years (1914–18) makes a total of 720 plates containing 263,157 stars. Thus the work on the four zones (-17° to -20°) originally allotted to the observatory has been completed.

The publication of vols. i. and ii. (zones -17° and -18°) was mentioned in last year's report.

Zone -19° was completed in 1919 January; the whole of the proof has now been read and passed for press, and the volume will be ready for distribution shortly.

In zone -20°, the remaining plates have been measured and reduced; the copy for press is being despatched to the printers in small batches. It is hoped that the volume will be published during the present year.

Some time ago Professor Turner, in the course of his studies of the Stellar Magnitude Scales of the Astrographic Catalogue, raised the question whether there is any systematic difference between plates taken from an observatory in the northern hemisphere and those of the same region taken from an observatory in the southern hemisphere (see *Monthly Notices*, 79, June). He suggested that for this purpose zone -22°, the plates of which are being taken at Santiago and measured at Oxford, may be taken and measured again at Hyderabad. Sanction of the Government was obtained for the undertaking, and the work was immediately commenced. 18 plates containing 5,598 stars have been measured, to the end of the year.

It is intended to include the intermediate zone -21° also in the programme of work. For this purpose the Standard Co-ordinates of the Reference Stars for the Zone from the Algiers A.G.C. have been computed; but no further work has been done at present.

The instrumental equipment remains the same as in previous years.

Kodaikánal and Madras Observatories.
(Director, Mr. John Evershed.)

Dr. Royds was released from his work on deputation to the Director of Ordnance Factories, Calcutta, and rejoined the staff of Kodaikánal on August 4th.

The routine work of the observatory was continued on the usual lines. Spectroheliograms in K light were taken on 329 days, Hα images on 231 days, and photoheliograms on 333 days.

The large grating spectrograph was actively employed during the year in photographing solar and arc spectra.

A continuous series of spectra of sunlight and Fe arc was taken to test the constancy of the Sun-arc displacement, and some remarkable variations in the shifts of the lines were demonstrated. Measures of the distances separating iron lines in the Sun, and similar measures of the arc spectra, show that in most cases anomalous displacements are due to a slight instability of wave-length in the arc lines, even those that are not subject to pole effect. In a few cases there is evidence that some of the solar lines are not absolutely fixed in their relative positions in the spectrum. Photographs of the iron arc under various conditions also indicate small changes of wave-length of the order of a few thousandths of an angström.

Experiments designed to indicate the causes of these anomalies have all given negative results. It is thought they may be due to changes in composition of the rods of impure iron or steel used as pole pieces, or they may have significance in relation to the recent discovery that differences of wave-length of the same order are found in the spectra of the isotopes of lead.

Displacements of Lines and Einstein's Prediction.—Measures have been made by Mr. Narayana Aiyar of the displacements at the Sun's polar limbs of the nitrogen bands near 3883. Fifteen plates of the limb spectra and carbon arc and ten plates of the spectra at the centre of the disc give the following mean displacements of ten prominent triplet bands:—

	In Angströms.	In Km/sec.
North limb . . .	+0·0061	+0·47
South limb . . .	+0·0088	+0·68
Centre of disc . .	+0·0043	+0·33

These values are very much larger than were obtained by St. John for other groups of lines in the carbon arc spectrum, and taken by themselves they appear favourable to Einstein's theory. The systematic difference between north and south indicates that the displacement may be variable.

Measures of limb spectra in high latitudes and with iron arc comparison also show the difference between north and south, although these were photographed a year later than the carbon arc spectra. The results of this series of plates, taking the mean of ten lines, is as follows:—

	In Angströms.	In Km/sec.
North limb . . .	+0·0099	+0·67
South limb . . .	+0·0134	+0·91
Centre of disc . .	+0·0070	+0·47

All of these results are free from pole effect in the arc and from pressure shift. Our previous researches having shown that pressure does not affect the displacements of the iron lines in the Sun, our results for these lines should be considered to be as important a test of the relativity theory as the measures of the nitrogen band lines.

The general result that both band lines and iron lines are displaced at the limb by amounts that, if not in exact agreement with the predicted amount, are of the right sign and order of magnitude appears favourable to Einstein's hypothesis. But the displacement differs for different substances and for different lines in the same substance; and previous work has shown that there is no proportionality between displacement and wave-length. If Einstein's hypothesis be true, therefore, there must be an unknown modifying influence at work.

The measures of Venus spectra offer the most serious difficulty, for they appear to show that the line displacement only occurs in the light derived from the hemisphere of the sun facing the Earth.

The hypothesis that motion in the line of sight is the only cause of the line displacement has this great advantage, that all of the anomalies mentioned, including the Venus results, are readily explained. But it involves a controlling action by the Earth which is very difficult to believe.

Venus Spectra.—Between February and June twenty-one plates of Venus and Fe arc were obtained, with the planet an evening star; and in November and December eight plates with the planet near western elongation. Eleven of the earlier series which should have given decisive results with regard to Einstein's hypothesis are defective owing to an instrumental defect, which was not remedied until April. The remaining plates yield results favourable to the motion hypothesis and against Einstein. It is hoped to get decisive results in 1920 February and March.

Rotation of Venus.—The inclination in the lines of the Venus spectra found in many plates appeared to indicate a direct rotation of the planet in a period of between 20 and 30 hours, but further investigation has shown that this is probably due to partial illumination of the spectrograph slit when the image is above or below its mean position. Owing to this uncertainty nothing can yet be said regarding the true rotation period.

Irregular Displacements of Lines on the Disc of the Sun.—Photographs of sections of the Sun's disc have been made in the Hα region, and the region studied in the Sun and Fe arc plates. It was found that the irregular displacements discovered in 1918 may be observed at the centre of the disc, but up to the present they have not been found near the limb. It appears therefore that, unlike the displacements in the penumbræ of spots, they

may be due to movements normal to the surface, or having a component normal to the surface.

Madras Observatory.—The transit instrument and the 8-inch equatorial telescope were cleaned and completely overhauled in December, and the dome of the equatorial was made to rotate satisfactorily by removing one of the supporting wheels in order to put more weight on the driving wheel, and give it some resilience. This method had been found quite successful in the case of another troublesome dome at Kodaikánal. Tests of the solar definition and the definition of stars in daylight were made with the 8-inch. As in previous trials, the seeing was found to be extraordinarily good near midday, and it is considered that these observations have, with others, demonstrated the immense advantage for solar work of the proximity of the sea, or of other extended water surfaces.

Publications.—Bulletins Nos. 60 and 61, dealing with the half-yearly distribution of the prominences, were issued during the year, but only a limited number of copies were distributed outside India.

Union Observatory, Johannesburg.
(*Director, Mr. R. T. A. Innes.*)

Staff.—There has been no change. Mr. E. L. Johnson has returned from military service in Europe, and the staff is now restored to its previous strength.

9-inch Refractor (Mr. Innes).—Measurements of double stars and observations of the eclipses of Jupiter's Satellites have been continued. A few miscellaneous observations were also made.

Franklin-Adams Star-Camera (Mr. Wood).—The following minor planets have been photographically observed: 31, 43, 80, 111, 123, 193, 371, and 758. Plates have also been taken for reproduction in the Observatory Circulars.

Twin Telescope (Mr. Worssell).—A few additional spectrographs of Nova Aquilæ have been obtained. Parallax plates of some stars having large proper motion have also been taken; this work will come to a conclusion early in 1920.

2⅝-inch Talcott Telescope (Mr. Worssell).—This instrument has been used throughout the year for the purpose of maintaining the time-service.

Blink Microscope.—As in the previous year, work with this instrument has been almost continuous. The Sydney zones to -59° inclusive have now been finished, and the results for the four zones -53°, -55°, -57°, and -59° are being prepared for press. By kind permission of H.M. Astronomer at the Cape, Mr. Wood paid third and fourth (final) visits to the Cape for the purpose of taking repeat chart plates, and got 115 and 112 pairs respectively; these are now being observed with the Blink micrometer, but will take about a year to finish.

About fifty stars having proper motions larger than $50''$ per century have been found during the year.

Dr. Baldwin has lent two-thirds of the zone $-66°$ chart plates with from 20 to 24 years' interval, and these have all been observed; the remaining third of the zone is expected daily.

Dr. Baillaud has lent a pair of plates which had undergone a thorough investigation by MM. Le Morvan and Jekhowsky. The results of the observations made here will appear in Circular No. 47.

M. Gonnessiat lent three pairs of Algiers plates, and will lend another three pairs; it is hoped by means of these six pairs to be able to disentangle the Solar drift from Drift I. The regions selected are about 2^h, $-2°$ and 8^h, $-1°$. The thanks of the Observatory are due to these astronomers for their ready willingness to supply it with such valuable material for measurement. Incidentally, some counts of stars on the plates of the Sydney zone have been made so as to determine its galactic condensation.

Meteorological and Seismological Observations.—These have been continued on the same lines as in previous years.

Observatory Circulars.—Nos. 44 and 45 were issued during the year. The chief contents of these are observations of Comet 1918 I. (Reid) and of minor planets. With these circulars six maps of southern regions were distributed. Circular No. 46 is in print, and Circular No. 47 in MS. is in the Government printer's hands.

Miscellaneous.—The preparation of the MS. of a General Catalogue of Southern Double Stars is practically finished, but publication is being delayed in the hope that the Henry Draper Catalogue of Magnitudes and Spectra will soon be available, and the valuable data it will yield can be made use of. The costs of paper and printing have risen so greatly that the Government has not yet formally sanctioned the publication.

It is hoped to accelerate the issue of the Southern Sky maps; many have been prepared for the printer, but the process of reproduction is a slow one.

Lovedale Observatory, South Africa.
(*Dr. Alex. W. Roberts.*)

Regular observations during 1919 were strictly confined to the observation of short-period stars only. There are 28 stars of this class on the Lovedale observing list, and 1190 estimates of brightness were made during the year. Most of these stars have been under continuous observation for 26 years.

Besides the regular work of observing variable stars, the determination of the brightness of stars above 6·0 mag. was proceeded with. Five standard southern regions have been compared with a northern group in Hydra; and these standard stars have been related again *inter se*. The mean relative magnitude of each region is thus determined within

$\pm 0{\cdot}024$ mag.

The ever-recurring difficulty, however, of an absolute standard of light magnitudes arose early in the investigation. Through the very great kindness of H.M. Astronomer at the Cape, and of Dr. Halm, a diffracting photometer was constructed at the Cape which seems to solve the difficulty. The errors and deficiencies of the instrument are at present under investigation.

Adelaide Observatory.
(*Director, Mr. G F. Dodwell, Government Astronomer.*)

During the past year the work of this observatory was set back through the loss of both the transit observers, one of whom left early in the year, and the other afterwards also decided to withdraw from the Government service. Considerable difficulty is being experienced in permanently filling the vacancies, and up to the present time only temporary appointments have been made. In August, however, Mr. C. A. Maddern, who had been at the front for $4\frac{1}{2}$ years, has returned to the observatory.

Meridian and Time-Service.—The transit-circle telescope was used for observation of clock stars and some of the intermediate stars in the Sydney zone (-52° to -64°). The number of observations is shown in the following table:—

	Observations in R.A.	In Declination.
Intermediate stars . .	544	548
Clock stars . . .	724	
Azimuth stars . . .	77	
Totals .	1345	548
Determinations of collimation	93	
,, ,, level	293	
,, ,, nadir point	44	

Azimuths were also determined from high and low stars north of the zenith.

Numerous observations of level were made in connection with the study of its dependence on the water content of the soil on the east and west sides of the building respectively. It has been proved that this is the principal factor in the fluctuations of level of the Adelaide transit-circle. The west side is most exposed to the weather, and falls relatively to the east side during the summer, rising again in the wet season. The changes cause cracks to develop in the walls of the building, particularly during long-continued dry weather. This phenomenon is characteristic also of buildings in general in Adelaide except those which have very deep foundations. By supplying water to the ground on the west side of the transit room, to compensate for the loss by evaporation during the summer months, it has now been found possible to keep the transit level in equilibrium.

The time-ball at the Semaphore was dropped at 1 p.m. daily, (Sundays, Christmas Day, and Good Friday excepted), the fall of the ball being recorded at the observatory by return signal automatically sent by the time-ball mechanism. As an additional check, the fall of the time-ball has also been recorded on clear days by an officer watching with the aid of a telescope on the observatory tower.

The time-ball at Port Pirie has also been dropped at 1 p.m., this service being in the charge of the assistant harbour-master at the port, who receives the midday wireless signals from Adelaide by means of a wireless receiving apparatus installed at the Port Pirie time-ball station. This system has worked very well during the past year.

The wireless time-signals for shipping (those of the Onogo system) have been sent out at midday and midnight each day from the Adelaide Radio Station, which is in telegraphic communication with the observatory. The signals proceed from the observatory mean-time clock and are automatically transferred to the wireless circuit. They are also recorded at the observatory, together with the beats of the standard sidereal clock at the moment of emission.

Latitude, Longitude, and Magnetic Observations.—Owing to the temporary depletion of the observatory staff it was not possible to undertake any field observations this year, but headway was made with computations of results of previous observations, and in addition graphs for facilitating almucantar computations (hour angles, azimuths, and the factors Z, L, and D) for latitudes 26° to 40° and declinations 75° to the equator were constructed and have been partly printed. Assistance in this work was derived from tables published by the Surveyor-General at Adelaide and from manuscript tables kindly lent by Mr. C. J. Merfield of Melbourne.

Australian Longitudes and Interstate (S.A.–W.A.) Boundary, 129th Meridian E.—In 1919 January the W.A. Government requested the Government of South Australia to join in fixing the common boundary line, defined by Imperial Act as the 129th degree of longitude east of Greenwich. It was decided that an initial point on the meridian should be determined by astronomical methods at the spot where the East-West Trans-Australian Railway line crosses the meridian, and that the line should be marked on the ground north and south of this point by the Survey Departments of the two States concerned. The South Australian Government wished to have the initial point determined with the greatest accuracy attainable by the use of modern methods, and agreed to a proposal involving the redetermination of a fundamental longitude for Australia, to be obtained by direct connection with Greenwich through the use of longitude signals transmitted by wireless from a high-power radio station intermediate between England and Australia, and received simultaneously at both ends. The co-operation of the Commonwealth Government and of the Government Astronomers of New South Wales and Victoria in

addition to those of Western and South Australia was therefore invited, and a comprehensive scheme involving the re-determination of the Australian longitude system was outlined. The Commonwealth Government agreed in the first instance to assist in preliminary experiments to test the possibility of simultaneous reception of wireless time-signals at Greenwich and an Australian prime station, and invited the co-operation of the British Government and through them the American Government. The New South Wales Government also promised financial support for the undertaking. Two conferences have been held in Melbourne, and a provisional committee consisting of the Government Astronomers of N.S.W., Victoria, W.A., and S.A., the Commonwealth Surveyor-General and Radio-Commander Creswell, Director of the Royal Australian Navy Radio Service, has been formed for carrying out the Australian part of the work. Sydney Observatory has been selected as the Australian Station to be connected directly with Greenwich, and a plan of operations has been discussed. The support given by the Astronomer Royal to the proposals and to the preliminary work is greatly appreciated in Australia. It has been reported that signals from Lyons can be successfully received in Australia as well as at Greenwich when the conditions favourable for wireless reception in Australia prevail, and signals from other stations more symmetrically situated are also being tested. It is hoped that the Australian longitude determinations may be linked up with the international longitude work initiated by the French.

Seismology.—The Milne seismograph was continually at work during the year, and tabulated records are being forwarded to Professor Turner for the Seismological Committee of the British Association for the Advancement of Science.

Miscellaneous.—The Board of Visitors met at the observatory on December 15. The Equatorial telescope has been used principally in connection with the public visits to the Observatory on Friday evenings. Mr. E. Farrow and Captain Snewin have done preliminary work at Semaphore in connection with latitude variation observations with instruments lent from the observatory.

Melbourne Observatory.
(*Dr. J. M. Baldwin, Government Astronomer.*)

Transit-Circle (*8-inch*).—During 1919 no programme of work was carried out with this instrument, observations being restricted to those for local time.

	Observations in R.A.
Clock stars (evening)	299
Clock stars (day)	281
Azimuth stars	29
Total	609

The southern collimator has been redesigned so as to permit of its use in conjunction with the long-focus lens of the southern meridian mark; the long-focus lens, the old collimator lens, and the collimator breech-piece have been mounted separately on the old collimator pier, and arranged so that while the long-focus lens is rigidly fixed to the pier, the other lens and the breech-piece can be turned out of the way when the meridian mark is to be viewed, and replaced in position for collimation.

An agricultural drain has been made round the pier carrying the meridian mark, and from present indications it appears that the system adopted for the lenses will be quite satisfactory, and the meridian mark stable.

A series of observations for pivot error was carried out in October, but the results, although indicating that the pivot error was small, also indicated that the testing telescope as supplied was not sufficiently rigid, as indeed was feared from the outset. A more rigid mounting for the testing telescope will be constructed and the pivot error redetermined during the coming year.

Astrograph.—The chief work with the astrograph has been the completion of the plates with 30 minutes exposure with centres along $-66°$, for Mr. R. T. A. Innes. When these were completed, a new observer was assigned to this instrument, and a start has been made on the remaining plates of the Carte du Ciel. The number of plates taken has been—

Zone $-66°$	45
Triple exposure chart . .	2
Rejected	14
Total . . .	61

6-inch Doublet and the 4-foot *Reflector* have not been used during the year.

8-inch Equatorial.—988 observations of variable stars of long period have been made, and the results forwarded to Harvard College Observatory each month. The number of variable stars now on the observing list is 77.

Reduction of Meridian Observations.—In the preparation of the supplementary catalogue of reference stars for the astrographic plates, catalogue positions of 850 stars for 1900 have been prepared. The apparent R.A. of all stars to 1918 December 31 is very nearly complete, and the apparent Dec. is complete to 1918 July 31.

The mean places of the stars in the zone $-64°$ to $-67°$ are complete, and the star reductions have been computed to the end of 1917.

Proper motions for the catalogue of 6089 stars for 1900 have been completed for the zone $-64°$ to $-69°$ for the first 6 hours of R.A.

Reduction of Astrographic Plates.—The measured co-ordinates and diameters have been copied out for the printer to $23^h\ 40^m - 68°$.

The plate constants have been computed to $6^h\ 54^m - 66°$.

The intercomparison of overlapping plates has been completed to $10^h\ 12^m - 66°$ with $10^h\ 10^m - 67°$.

Magnetic Observations and Reductions.—The new magnetic variation observatory at Toolangi was completed during the year, and the Eschenhagen instruments have been in operation there since the beginning of August. The daily attendance is performed by one of the residents of the locality, but visits are made each month for determination of scale values, etc. The functioning of the instruments has been satisfactory except for the vertical force instrument, which is liable to be overturned by mechanical shocks. The records with the Adie instruments at Melbourne were discontinued at the end of the year.

No curves have been measured, but the classification of the curves has been forwarded quarterly to De Bilt.

The absolute value of the earth's magnetic field was determined 22 times during the year, the means of the observed values being:—

	D.	H.	I.
1917	8° 3′·2 E	·22961	67° 50′·9
1918	8° 2′·6 E	·22940	67° 51′·7
1919	8° 1′·0 E	·22895	67° 53′·8

The results for 1917 and 1918 are given for comparison.

Seismograph.—The records have been read off and the results forwarded to University Observatory, Oxford.

Weights and Measures.—The comparison of the copies No. 18 (New South Wales) and No. 40 (Victoria) of the British Fundamental Yard gave (18) = (40) − ·00016 inch. The results deduced from the original comparisons of sixty years ago was (18) = (40) − ·00009 inch. This relative change of ·00007 inch is comparable with the changes shown by the Parliamentary copies.

Owing to one of the terminal lines of the copy, No. 37 (Tasmania), being almost entirely obliterated, no use could be made of it in this comparison.

Assuming the mean of (18) and (40) to have remained unchanged, the present comparison shows that the Victorian Primary Standard Yard is too short by ·00149 inch at 62° F., whereas the data furnished with the bar indicate that it was too long by ·00171 inch at 62° F.

Miscellaneous.—The time-service, registration of tides, and various miscellaneous services have been continued as in 1918.

The staff has been still further reduced by the resignation of Miss Peel (assistant computer), and no fresh appointment to this or other vacancies has been made, so that the lack of sufficient assistance is even more pronounced than last year. Once more no funds are available either for temporary assistance or for publication.

Sydney Observatory.
(*Director, Mr. W. E. Cooke, Government Astronomer.*)

The principal work has been the observation of the intermediate stars situated between 51° and 65° S. declination. This was commenced on 1918 March 11, and the observational part is practically completed. The number of stars is 1069, and with few exceptions each has been observed ten or more times. The total number of observations is 11,311, of which 6583 were taken during 1919.

The observations are completely reduced to January 1, and computation of the precessions, etc., is well forward. A considerable amount of work, however, still remains to be done, *e.g.* determination and application of graduation and pivot errors, magnitude equation, personal equation between fixed and movable wires, reduction to standard epoch, preparation for press, etc. This will be taken in hand almost immediately.

During the year a limited supply of plates for the astrograph came to hand, and work has recommenced. At present only a start can be reported, but an attempt will now be made to push this portion of the work as vigorously as possible.

The usual routine duties, including University lectures, time-service, seismograph, reception of visitors, etc., have been maintained as heretofore.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1919.

Planets were discovered or first announced in 1919 as follows:—

Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer.	Letter and Number.	Date.	Discoverer
	1917.			1919.			1919.	
d	Dec. 3	1, 7	FL 913	May 19	2	FZ	Sept. 22	2
	1918.		FM	June 26	6	GA	18	2
a	Mar. 4	5	FN 914	July 4	6	GB	30	2
b	Dec. 14	9	FO	5	2	GC	Oct. 20	2
	1919.		FP	5	2	GD	22	6
FA 909	Feb. 7	2, 4	FQ	Aug. 19	2	GE	23	2
FB 910	Mar. 1	2	FR	22	2	GF	23	2
FC			FS	22	2	GG	Sept. 1	2
FD 911	19	2	FT	Sept. 1	2	GH	Mar. 25	3
FE	Apr. 2	2, 3	FU	1	2	GJ	Dec. 11	2
FF	2	4	FV	4	2	GK	Oct. 18	8
FG	20	2	FW	18	2			
FJ 912	27	4	FX	22	2			
FK	May 4	4	FY	22	2			

The discoverers are:—

(1) Dr. Curtis, Lick Observatory.
(2) Mr. K. Reinmuth, Königstuhl Observatory, Heidelberg.
(3) Dr. R. Schorr, Bergedorf Observatory.
(4) Mr. A. Schwassmann, Bergedorf Observatory.
(5) M. Sy, Algiers Observatory.
(6) Professor M. Wolf, Königstuhl Observatory, Heidelberg.
(7) Miss Young, Lick Observatory.
(8) Señor Comas Sola, Barcelona.
(9) M. F. Gonnessiat, Algiers Observatory.

The following planets, discovered in 1918 but unnumbered at the date of the last Report, have received permanent numbers:—DU 895, DV 896, DZ 897, EA 898, EB 899, EC 900, EE 901, EJ 902, EM 903, EO 904, ES 905, ET 906, EU 907, EX 908.

The following identities have been established:—901 with 1905 SA, 903 with 1913 TM, 904 with 1913 TG and 1916 Σ36, 1919 EZ with 227, 1919 FH with 245.

The following identities are more or less probable:—910 with 1902 KS, 912 with 1911 NN, 1918 EQ with 1902 JA, FU with 614.

Planet 911 is a sixth member of the Trojan group, its longitude being some 60° greater than that of Jupiter. 898 has a large eccentricity, nearly 0·4; the inclinations of 895 and 914 exceed 25°.

Investigations of the orbits and perturbations of the following planets have been published:—24 Themis by Mddle. Julie M. Vinter-Hansen (*Ast. Nach.*, 4999); 352 Gisela by Mr. Karin M. Schultz (*Ast. Nach.*, 5006); 447 Valentine by Mr. H. Osten (*Ast. Nach.*, 5026).

Mr. G. Stracke gives in *Ast. Nach.*, 4992, revised elements of Alinda, which is of special interest from its very large eccentricity and small perihelion distance. Epoch and osculation 1918 March 15·5 G.M.T., equinox 1918·0, M 17° 19′ 17″·65, ω 347° 48′ 54″·11, Ω 110° 53′ 2″·90, *i* 8° 57′ 37″·24, φ 32° 13′ 41″·85, μ 880″·0953, log *a* 0·4036512, *q* 1·182210. Its nearest approach to the Earth's orbit is just $\frac{1}{5}$ of an astronomical unit.

M. Paul Stroobant, Director of the Royal Belgian Observatory of Uccle, has recently published a Memoir on the minor planets, in which he brings out forcibly the remarkable grouping of perihelia and nodes with respect to the orbit of Jupiter. He also makes an estimate, by two entirely different methods, of the total number of minor planets brighter than the 20th magnitude. The results are 57,000 and 100,000, which are in satisfactory accord, considering the large amount of extrapolation involved. He considers that very few planets brighter than the 12th magnitude remain undiscovered. A. C. D. C.

Comets.

Two periodic comets, Borrelly's and Schorr's, were still under observation at the beginning of 1919. No further cometary discovery was made till July 30, when Professor Max Wolf found Kopff's periodic comet (1906 IV.), which had not been seen since 1906. It had passed perihelion on June 28, and was at no time conspicuous, but it remained under observation for about six months.

Comet 1919 *b* was found on August 20 by Dr. Metcalf; it was soon noticed by Professor Leuschner and others that it was identical with the comet of the Neptunian group, 1847 V., Brorsen; its return was several years earlier than was expected, the mean of several determinations of its period being 76·2 years, and the one that was considered most reliable (Gould's second determination) being 81·1 years. The comet was only visible for two months in 1847, and, being a diffused object, it was difficult to ascertain the period with accuracy; the observed period is 72·1 years. The comet passed within 20 million miles of the Earth on September 6, and was a fairly conspicuous naked-eye object in the circumpolar constellations. Mr. Longbottom photographed a

straight thin tail, 5° in length. The comet was observed till the end of November, and may still be under observation in the Southern Hemisphere. Five members of the Neptune comet family have now been observed at a second apparition. Besides the above and Halley's Comet, these are Pons-Brooks, 1812 and 1884, period 71·36 years; Olbers, 1815 and 1887, period 72·45 years; Westphal, 1852 and 1913, period 61·12 years. There are two other members of the family that have not yet been observed at a second apparition: Comet 1827 II. (Pons-Gambart), for which Mr. Ogura found a period of 64 ± 5 years, and de Vico's Comet, 1846 IV., which is expected back at perihelion in 1921 November; the period is uncertain by 3 years.

Comet 1919 *c* was found on August 22 by Dr. Metcalf, and independently, one day later, by M. Borrelly. It was an easy telescopic object in the autumn, but never became visible to the naked eye; it may still be under observation in the Southern Hemisphere. The orbit does not deviate appreciably from a parabola.

Comet 1919 *d* was found by Mr. Sasaki at Kyoto, Japan, on October 25; a few days later M. Fayet announced its identity with Finlay's periodic comet, which had not been seen since 1906. The present return was a very favourable one, the comet approaching the Earth within about 20 million miles on November 8, just two months after Comet *b* had made a similar approach. It was an easy telescopic object, and was very well observed.

Comet 1919 *e*.—This was Schaumasse's periodic Comet 1911 VII.; M. Schaumasse himself detected it on October 29 with the aid of a search ephemeris made by himself and M. Fayet. It was of magnitude 12·0 at discovery, and growing fainter, so that observations have not been numerous.

Comet 1919 *f* was found by Dr. Baade at Bergedorf, Hamburg, on December 10 in the course of a photographic search for Holmes's Comet. It was recorded on two plates, and its motion in declination was too different from that of Holmes's Comet for identity to be possible. No further observations were obtained.

Comet 1919 *g* was found by Mr. J. F. Skjellerup at the Cape Observatory on December 18. It was photographed by Mr. R. Woodgate on two days. The magnitude at discovery was 8·5.

The following are the elements of the orbits of the above comets:—

Comet.	Kopff.	Brorsen. Metcalf.	Metcalf. Borrelly.
Computer.	Ebell.	Braae. Fischer-Petersen.	Vanderlinden.
T in G.M.T.	June 28·210	Oct. 16·877	Dec. 7·272
ω	19° 43′ 51″	129° 30′ 39″	185° 49′ 37″
Ω	263° 48′ 51″	310° 44′ 28″	120° 59′ 14″
i	8° 41′ 30″	19° 11′ 39″	46° 23′ 30″
log q	0·232118	9·685628	0·046698
e	0·514204	0·971349	1·000000
Period	6^{y}·5841	69^{y}·628	∞

Comet.	Finlay.	Schaumasse.	Skjellerup.
Computer.	Crawford. Fairfield. Cummings.	Mahnkopf.	Halm.
T in G.M.T.	Oct. 15·524	Oct. 20·7	1920 Jan. 2·674
ω	318° 14′ 52″	45° 36′ 30″	276° 35′
Ω	46° 54′ 47″	91° 19′ 6″	315° 36′
i	3° 23′ 22″	15° 17′ 30″	123° 10′
log q	0·005615	0·08500	9·47376
e	0·714630	0·69517	1·00000
Period	6^{y}·6882	7^{y}·969	∞

The year 1919 is to be understood before all the perihelia except the last. The fact of 3 out of the 7 comets passing perihelion within an interval of 5 days is noteworthy. The orbits are referred to the equinox of 1919·0 except the last, which is for 1920·0. The orbits of Kopff's and Finlay's Comets have been corrected by the recent observations; approximate corrections have been applied to Mahnkopf's values of T, e, and period for Schaumasse's Comet. The period 69·628 years is some $2\frac{1}{2}$ years below the true value for Comet Brorsen-Metcalf.

Mr. F. K. Zweck has made the interesting discovery that the object previously known as Comet 1908 *a* (in some Catalogues, Comet 1907 VI.) is identical with minor planet 516 Amherstia. The object was at first taken for Encke's Comet, afterwards for a new comet with a large perihelion distance. The orbits of Encke's Comet and Amherstia approach each other within 2 million miles in longitude 310°·6, and within 5 million miles in longitude 358°·4 (*Ast. Nach.*, 4990).

Ast. Nach., 4994, contains a paper by L. Hufnagel on the orbit of the great Comet 1882 II. Owing to its small perihelion distance and consequent great velocity, it seemed worth while to examine whether the Einstein law of gravitation would give a sensibly different orbit from the Newtonian law. The result is negative; the two orbits differ only by quantities that cannot be certainly determined in the case of poorly defined objects like comets. It is, however, worth while to give Mr. Hufnagel's results in some detail, both to show how slightly the Einstein and Newtonian results differ, even in an extreme case, and also to demonstrate how little evidence the observations give of any disturbance by resisting medium while passing perihelion, which occurred between the 4th and 5th normal places printed below. The distances of the comet from the sun's centre in solar radii and its velocity in miles/sec. have also been inserted in the neighbourhood of perihelion.

Both orbits are referred to the equinox of 1882·0, and T is expressed in Berlin M.T.

Computer.	Kreutz.	Hufnagel.
Law.	Newtonian.	Einstein's.
T	1882 Sept. 17·2613083	Sept. 17·2613095
ω	69° 35′ 16″·05	69° 35′ 18″·24
Ω	346° 0′ 38″·80	346° 0′ 39″·50
i	141° 59′ 44″·23	141° 59′ 44″·34
log q	7·8893177	7·8893384
e	0·9999078	0·9999068
Period	771ʸ·8	760ʸ·9

Comparison with Observation.

Date.	Calc. − Obs. Kreutz. cos δ Δα	Kreutz. Δδ	Hufnagel. cos δ Δα	Hufnagel. Δδ	True Anomaly.	Dist. from ⊙ centre in ⊙ radii.	Speed in miles per sec.
82 Sept. 8·5	+1″·70	+1″·65	+0″·75	+1″·44	−165° 5′	98·88	38·6
14·25	+2·52	+0·21	+2·26	+0·13	158 28	47·72	55·5
15·60278	+1·06	+0·81	+1·01	+0·77	153 26	31·56	68·3
16·61389	+5·79	−0·04	+5·90	−0·03	−142 35	16·20	95·3
17·26131					0 0	1·666	297·2
18·0	+2·43	+2·76	+2·54	+2·80	+144 23	17·81	90·91
19·0	+0·25	+0·50	+0·27	+0·51	153 52	32·61	67·19
20·0	+0·06	−0·29	+0·02	−0·28	157 44	44·69	57·39
21·5	+0·61	+0·40	+0·47	+0·40	+160 52	60·33	49·40
Oct. 1·5	−0·72	−0·87	−1·16	−0·90			
10·0	−0·90	−0·79	−1·39	−0·79			
22·0	−1·64	+0·43	−2·10	+0·45			
Nov. 4·5	−0·59	+0·98	−0·93	+1·09			
21·0	+0·57	−0·84	+0·53	−0·72			
Dec. 10·0	+0·10	+0·90	+0·36	+1·69			
83 Jan. 2·0	+2·00	+1·82	+2·29	+2·87			
23·0	+0·65	+0·36	+0·70	−0·16			
Feb. 7·5	−0·10	−3·01	−0·23	−3·19			
Mar. 3·0	−1·65	−0·94	−1·95	−0·90			

The comet approached the sun's surface within $\frac{2}{3}$ of a solar radius, which is considerably closer than the apparent distance of any of the stars at the eclipse of 1919 May 29.

A. C. D. C.

Solar Activity in 1919.

It is now evident that the maximum sun-spot activity was reached in 1917; the lower average latitude of the spots during 1919 and the decrease, both in the mean daily spotted area and in the size

of individual groups, is strong evidence that the maximum has been passed. Nevertheless, the year 1919 proved to be an active period, and the estimated value of 900 millionths for the mean daily area makes it comparable with the phase of the last cycle during 1907 and 1908. The month of greatest spotted area was June, although on some days during March, May, and August the maximum area of about 2500 millionths was reached. In June, however, the activity was more consistently maintained than in other months. After August the spot activity steadily declined, and the December record was comparatively insignificant.

On some occasions, in June especially, the spot and facula disturbances formed two nearly continuous belts, north and south of the equator respectively; at other times (*e.g.* June 28) four or five areas were active on the same meridian. But perhaps the most striking area of activity was observed during August, in the neighbourhood of longitude 100° and latitude $-2°$ to $+15°$; and on August 21 this area contained spots exceeding 2000 millionths in total area. The nucleus of this region showed continued activity in succeeding rotations until December 7.

The "regular spot" was a dominant feature of the year, as the leader of the "stream" type of spot groups and also as an unaccompanied spot. Several of these spots had areas of 400 millionths, while in June a giant spot, which approached the regular form, reached nearly 1200 millionths. A close pair of regular spots—an unusual phenomenon—was the chief interest during September. The "complex" class of spots was represented by that of May 13–25, which, after showing considerable development between May 15 and 16, attained an area of about 1800 millionths.

H. W. N.

The Prominences.—There has been a slight decrease in prominence areas and a considerable reduction in numbers compared with the previous year. The mean daily areas derived from the Kodaikánal photographic records are as follows:—

	North.	South.	Total.
1919 January to June . . .	1·55	1·81	3·36
July to December . .	1·96	2·09	4·05

The mean daily numbers recorded decreased from 13·6 for the first half of 1919 to 11·2 for the second half; the decrease is mainly in the number of small prominences.

Prominence activity has been considerable in the equatorial regions and as far as latitude 40°; beyond this latitude a rapid decrease is shown, and at 60° the activity practically ceases. Between 60° and the poles very small prominences or transient jets were recorded.

Metallic prominences greatly increased in frequency compared with the year 1918, and prominences showing displaced lines were also more frequently recorded than in the previous year. No displacement exceeding 6 Ångströms at Hα was seen. There was

the usual slight excess of displacements towards red, 54 per cent. of the whole number showing motion away from the earth.

Prominences projected on the disc as absorption markings gave the same latitude distribution as those observed at the limb. The mean areas are about 3 per cent. and numbers 17 per cent. less than in 1918; the decrease is therefore mainly in the number of smaller markings, as in the prominences at the limb.

The largest prominence photographed during the year attained its greatest development of 12 square minutes of arc on May 29, when a great part of it became detached from the sun and ascended into space. The angular rotation speed when the prominence was visible as an absorption marking between May 7th and 13th was found to be 14°·28 per diem, in agreement with the rotation speed of the reversing layer. J. E.

Solar Research in 1919.

Solar Periodicity.—F. Schuster has suggested (*Ast. Nach.*, 208, 5) a period of 9·3 years, which coincides with half that of the revolution of the moon's nodes and also with that of Unterweger's "comet function," depending on the inclination and perihelion distances of comets. His analysis is not adequate to convince in view of the existence of other periods, and in view of the close dependence of the cometary results on one period. The conclusion as to the dependence of sun-spot frequency on outside bodies is not novel. S. B. Nicholson (*Proc. A.S. Pacific*, 31, 223) discusses the sun-spot activity of the late cycle. The curve closely resembles the Cepheid light curve. The points of interest are the prolonged minimum and the rather long interval, 12·5 years, between the two maxima. The Greenwich observers (*M.N.*, *R.A.S.*, 79, 446) have drawn attention to the presence of secondary maxima in the summer of 1915, and in the spring and summer of 1916. A. M. Newbegin (*B.A.A.J.*, 29, 190) notices a progression polewards of the principal zones of prominence activity towards maximum.

Sun-spots.—E. W. Maunder (*M.N.*, *R.A.S.*, 79, 451) has examined the life-history of the important individual spot-groups of 1915. He shows a general tendency for the leader spot of a group to advance in heliographic longitude, while the rear spot retrogrades or is stationary in longitude. After the leader halts in longitude the group begins to decay: the leader survives as a circular spot, stable in area and with a slight tendency to slow retrogression in longitude. S. B. Nicholson (*Proc. A.S. Pacific*, 31, 277) describes two very interesting spots seen in August 1919. One, 6° north of the equator when first seen, was a large leader spot with a well-developed stream; the other, 3° south of the equator, was a small spot-group whose leader was developing rapidly. The northern leader drifted south, and the southern leader expanded until both penumbræ reached the equator, when the spots disappeared round the west limb of the sun. On re-

appearance the leaders alone survived unchanged in position. The umbræ were some 30,000 miles wide, and their centres 33,000 miles apart. Apparently they were unable to cross the equator. The magnetic polarities were normal, being of opposite sign to each other, and of the field strengths about 3000 Gauss.

The magnetic polarity of sun-spots has now received a prolonged study at Mount Wilson, and Hale, Ellerman, Nicholson, and Jay have given (*Ap. J.*, 49, 183) a full account of the results so far reached. Their view is that the sun-spots represent vortices in which electrified particles are whirled with great velocity. The vortical structure first shown in photographs was confirmed by the Zeeman effect. We have simultaneously present high-level hydrogen vortices centred over the spots and low-level vortices in the photosphere forming the spots themselves. In the hydrogen vortices we have motion spirally inward and down with probably an outward flow in the lower chromosphere. In the spots we have motion spirally upward and outward along the sun's surface. The polarity of the spots is that shown by the portion of the spot nearer to the centre of the sun's disc, and the lines of force are nearly radial in the sun. Several laws of polarity have been determined. The polarities of the preceding spot, of the usual bipolar group (or that of the less common unipolar spot), are different in the two hemispheres and changed over in both hemispheres at the minimum in 1912. No change occurred at the maximum of 1917. In a bipolar spot the leading and the following spot exhibit opposite polarities. The relation between the sun-spot whirls and the hydrogen whirls above is not clear. The latter did not change polarity at the 1912 minimum. A summary of this work was also given by Hale in *Proc. R.S.*, 95A, 234.

Sun's Magnetic Field.—The deviations of the sun's magnetic field from that of a uniformly magnetised sphere have been examined at Mount Wilson (*Proc. Nat. Acad. of Science*, 5, 242). The elements determining the sun's axis given by the 1916 observations confirm those of 1914. A fresh discussion of the data, not assuming a uniform field, shows irregularities in the field strength too large to be accounted for as systematic or accidental errors. Between $\pm 10^\circ$ heliographic latitude the field strength is about twice that found between 10° and 45° north or south latitude.

Solar Atmosphere.—In an article in *Nature* (103, 426), illustrated with photographs from Mount Wilson, the structure of the solar atmosphere is discussed. Special attention is devoted to the coarse dark granules or flocculi given in the highest layers ($H\alpha$ central) and the smaller ones in the low-level calcium layers (H_1 and K_1). It is suggested that the granules correspond to radial filaments in the chromosphere which expand as they rise. Ellerman (*Proc. A.S. Pacific*, 31, 16) in an account of the solar research at Mount Wilson gives some beautiful illustrations of the dark rifts on the disc near the edge, showing how they stand out as bright prominences on the limb itself. In an account of the various items of work allotted to the different instruments, he

mentions visual work on the Hα line round active sun-spot groups to observe distortions due to radial velocity and reversals over the bright hydrogen regions.

Prominences.—Several papers have appeared on the great prominence that was present on the day of the eclipse 1919 May 29. It was traced back by Pettit (*Ap. J.*, **50**, 206) to March 22, and seen by Evershed (*M.N.*, *R.A.S.*, **80**, 8) and Deslandres (*C.R.*, **168**, 1076) as a dark filament from May onwards. W. Moss secured twelve photographs at Cambridge (*M.N.*, *R.A.S.*, **79**, 553) covering the interesting phase when the prominence completed its extension in length and broke loose from the streamers connecting it to the limb. Acceleration of matter down to the equator and abrupt changes in the upward motion are indicated, and these are worked out in very considerable detail by Pettit from twenty-six plates secured at Yerkes. Pettit's conclusion, confirmed by observation of a very striking prominence on July 15, is that the main body of the prominence shows a series of uniform upward motions which change impulsively at irregular intervals to higher rates of motion. He confirms his previous view that prominence-producing regions rotate with the angular velocity of spots and of the reversing layer, and tend to renew prominences which have suffered complete dissolution.

Eclipse Results.—Photographs of the corona and prominence observed at the eclipse of 1919 May 29 are to be found in *The Observatory* (p. 405). The corona was a blend of maximum and minimum types. The northern half was of minimum form, with two great equatorial wings and polar plumes. There was a prominent streamer at the south pole. The inner corona showed a set of interlacing arches and a coronal ring round the prominence (Crommelin and Davidson, *M.N.*, *R.A.S.*, **80**, 12). The results on the deflection of the star images will be discussed elsewhere. Further results of the Crocker eclipse expedition from the Lick Observatory for 1918 June 8 have now been published (*L.O.B.*, 319). A further list of coronal lines (in addition to those referred to in last year's report) is given by Campbell and Moore for the range 3601 to 5303, and a flash spectrum for 3105 to 5214. Strong polarisation effects were found in the corona, which reached a maximum 5′ from the limb. The account contains a discussion of previous evidence on the coronal spectrum. The wave-length of the green coronal line as determined by use of a 3-prism slit spectrograph is given as 5302·98 (Rowland), as compared with 5303·20 determined by Adams, St. John, and Miss Ware from the same eclipse. There is an outstanding discrepancy.

J. Kunz and J. Stebbins (*Ap. J.*, **49**, 137) discuss their determination by the use of a photo-electric cell of the brightness of the corona at the Illinois expedition for this same eclipse. Four measures made during totality, and agreeing *inter se* within 8 per cent., give the brightness as 0·5 that of the full moon. The problem of detecting the corona in full daylight by this method is not hopeless (*Observatory*, **42**, 136), and Ellerman is already

experimenting at Mount Wilson, trying to trace the corona by the different effects on two photoelectric cells exposed to the sky near the sun (Mount Wilson *Report*, 1917–8).

At the same eclipse Aldrich (*Smithsonian Misc. Coll.*, **69**, No. 9) examined the sky radiation during totality and found it to be less than that of twilight one hour after sunset. The outgoing radiation to space during totality was found to be considerably in excess of the values obtained for nocturnal radiation on the following night when humidity and sky conditions were nearly identical.

Solar Radiation.—C. G. Abbott (*Proc. Nat. Acad. of Sci.*, **5**, 383) gives a preliminary report of observations made simultaneously at Mount Wilson and at Calama, Chile, to test the existence of short-period fluctuations in the solar constant. Irregular periodicity in the sun's radiation has been confirmed, and relations with terrestrial temperature, pressure, and weather conditions are being investigated.

Solar Spectrum.—New infra-red lines in solar prominence spectra are given by Kelvin Burns (*Proc. A.S. Pacific*, **31**, 317). The plates used were sensitised by dicyanin and they showed *He* 7065 strong, the *Ca* triplet at 8498, and the *Mg* line at 8807. The complete discussion by Fowler and Gregory of the Ammonia Band in the ultra-violet has now been published (*Phil. Trans.*, **218A**, 351).

Solar Rotation.—C. E. St. John and L. W. Ware give in *Popular Astronomy* (**32**, 98) an account of five years' observations taken with the same instruments, observers, and measurers to test for periodicity in the sun-spot cycle. So far there is no evidence of periodicity, only of temporary differences due to local conditions. Differences due to line intensity or level are confirmed. H. H. Plaskett (*Jour. R.A.S. Canada*, **13**, 391) replies to De Lury's criticism on the effect of haze on the determination of the solar rotation. He finds the correlation between brightness and low velocities of rotation too small to be significant.

Miscellaneous.—C. G. Abbott (*Ap. J.*, **50**, 295) answers the criticisms of Spijkerboer, Julius, and Van der Plaats given in *Études sur le rayonnement solaire*. He rejects their main criticisms on the ground that his meaning was misunderstood, and repeats his conclusions that the sharpness of the limb is due to the scattering of yellow light in looking through layers of gas tangentially. In the known darkening near the limb temperature is most important, as the effective radiating layer near the limb must be nearer the surface on account of scattering and must therefore be cooler. So far as the sun is a source of radiation to the earth, it is like a hollow shell of varying thickness.

A. Veronnet (*C.R.*, **168**, 398) discusses the maximum temperature possible at the centre of the sun. Under the conditions most favourable to high temperatures consistent with physical equilibrium and certain hypotheses as to a central nucleus and an atmosphere above obeying a different law, he reaches the figure 12600°, or twice the surface temperature. F. J. M. S.

The Eclipse of 1919 *May* 29 *and the Theory of Relativity.*

Two expeditions were sent from England to observe the eclipse, the special object of research being the testing of the deflection of starlight in the sun's gravitational field. Professor A. S. Eddington and Mr. E. T. Cottingham were stationed in the island of Principe, and used the 13-inch lens of the Oxford Astrographic Equatorial. Messrs. A. C. D. Crommelin and C. R. Davidson observed in Sobral, Brazil. They used the Greenwich astrographic lens, and a 4-inch lens of 19-feet focus lent by the Royal Irish Academy. The sky at Principe was cloudy for the greater part of totality, but two plates were obtained on which five stars could be measured. At Sobral the sky was clear for four out of the five minutes of totality, and the full number of stars was registered on most of the plates, viz. 12 stars on the astrographic plates and 7 on those taken with the 4-inch lens. The definition of the star images on the astrographic plates is very poor, owing probably to the distortion of the cœlostat mirror by the heat of the sun, as plates exposed at night a few hours earlier were in good focus. The images on the plates taken with the 4-inch lens were very satisfactory.

The Brazil party secured check-plates of the eclipse star field at Sobral in mid-July at nearly the same altitude as during totality. The Principe plates were compared with a check field near Arcturus, both that and the eclipse field having been previously photographed with the same lens at Oxford. The resulting deflections of starlight, reduced to the sun's limb, were:—

Principe	$1''\cdot60 \pm 0''\cdot30$
Sobral, Astrographic . . .	$0''\cdot93 \pm 0''\cdot30$
,, 4-inch	$1''\cdot98 \pm 0''\cdot12$

The predicted values are $0''\cdot87$ on the Newtonian theory and $1''\cdot75$ on the Einstein theory. The results were announced at a joint meeting of the Royal and Royal Astronomical Societies, held at the Royal Society's rooms on 1919 November 6; they will be printed in the Philosophical Transactions.

The meeting of the Royal Astronomical Society on 1919 December 12 was devoted to a discussion on the Theory of Relativity. It is fully reported in the *Monthly Notices*.

There was another discussion at the Royal Society on 1920 February 5. Much correspondence on the subject has been published in the columns of *Nature*, *The Observatory*, and elsewhere.

A report on the Corona and Prominence was published in *M.N.*, 80, 12. The great prominence was also discussed by Mr. Moss, *M.N.*, 79, 553, by Mr. Evershed, *M.N.*, 80, 8, and by Mr. Pettit in *Ap. J.*, 50, 206.

Variable Stars.

There was a very large output of variable star work in 1919. Numerous records of observations and the accounts of new discoveries will be found in the usual sources of such information, and it is impossible to make reference to them here. Mention may, however, be made of the large number of cluster variables recently discovered (H.C.O. 216, 217, and elsewhere), and attention drawn to the list of globular clusters for which photographs are needed, and which require examination for variables (H.C.O. 211).

In addition, several papers of theoretical and general interest have appeared, and a short summary of some of them is given in this note.

Long-period Variables.—In *M.N.*, **79**, 371, H. H. Turner in his third paper on "The Classification of Long-period Variables" deals with the influence of the period on the shape of the curves in Phillips's two classes. Making a slight modification of the division by taking the sign of $\cos \phi_2$ as the criterion of the group (assigning the stars to I. or II. according as this is positive or negative), he finds evidence of the fact that in both groups the stars with the longer periods have on the average low galactic latitudes—in other words, *they affect the Milky Way*! There is also a relationship between the character of the groups and the periods: *e.g.* in Group II. there is a well-marked fluctuation in the phases of the second and third harmonics as the period changes by multiples of 45 days, and there is a similar fluctuation in the "frequency" with which the stars occur at any particular period. Meanwhile the coefficients of the harmonics change steadily with the period, but without showing any indication of the 45 days' cycle. In Group I. both the phases and the coefficients of the second and third harmonics show gradual changes with the period, and there is a fluctuation in the "frequency" in cycles of 60 days.

In *M.N.*, **80**, 41, there is a paper of special importance by H. H. Turner and Miss M. A. Blagg on the "Long-period Variable *W Cygni*." A remarkable feature of this star is that it has two main waves (designated by θ and ϕ), with periods of 129·6 and 243 days which run concurrently, the former having the character of Group I. stars, and the latter that of Group II. stars. There is also evidence of a third wave with a period of 1944 days, or 15 times that of the first wave, and 8 times that of the second. Another interesting point is that the ϕ variation is waning while the θ variation is waxing, and it is suggested (1) that the star may be crossing over from Group II. to Group I., and (2) that this change of group may be a normal feature in the evolution of variables, which, in accordance with the correlation between the periods and the light-curves (*M.N.*, **79**, 371), starting at the top of Group II. with periods in the neighbourhood of 400 days, suffer a diminution of period to 200 days, and then, after crossing over into Group I. with periods of

about 150 days, show an increase of period again. In accordance with this suggestion, it is found that in general the Baxendell Stars of Group II. have decreasing and those of Group I. increasing periods.

In another paper (*M.N.*, **80**, 273) this hypothesis is put to a further test by an examination of Group II. stars, to which Chandler assigned secular terms in his 3rd Catalogue (revised), and for which sufficient data for discussion can be obtained from H.A. 55 and other sources. The result is in general accord with the hypothesis. In no case is there found to be a secular *increase* of period, though for two of the stars this was suggested by Chandler. It is, of course, only possible to discuss the question of secular changes in cases where the stars have been under observation for so long that the effects of temporary oscillations, which are often considerable, can be eliminated, but so far as the evidence at present available goes, it appears to fit the hypothesis.

Another point of great interest which has been brought out is that changes, when they occur, usually take place in sudden "jumps," either in period or phase, or both. *R. Hydræ* is a particularly interesting star, since it is *liable* to sudden diminutions of period of just 10 days at intervals of 3415 days. The star was found to be variable by Montenari in 1672, and since 11 of these "jumps" have now occurred, the period has been reduced from 518 to 408 days.

In *M.N.*, **79**, 572, J. G. Hagen, S.J., draws attention to the relation between (1) Pickering's grouping of the light-curves of long-period variables according to the characteristics of their maxima, minima, and rate of increase and decrease in magnitude, (2) H. H. Turner's classification according to the value of α in the equation

$$\alpha = \{2(M - m) - P\}/P,$$

and (3) Phillips's division of the stars into two groups according to the phases of the harmonics of their light-curves.

Taking Pickering's division as practically threefold under the designations (*a*) uniform variation, (*b*) broad minimum, (*c*) rapid increase, it is shown that there is a steady diminution in the value of Turner's α from (*a*) to (*c*), while Phillips's Group I. coincides with (*a*) and Group II. with (*b*) and (*c*).

W. Gyllenberg has contributed an important paper on the motions and distribution in space of the long-period variables in *Arkiv för Math., Astr. och Fysik* (Bd. **14**, 5). From his investigations he concludes that on the average the absolute magnitude of a long-period variable is probably $-0^m{\cdot}7$. These stars, however, do not appear to have the exceptional brilliance shown by the Cepheids of corresponding spectral type.

Short-period Variables.—The second part of A. S. Eddington's discussion of "The Pulsations of a Gaseous Star and the Problem of the Cepheid Variables" is published in *M.N.*, **79**, 177. In Part I. (*M.N.*, **79**, 2) the conclusion was arrived at that on the

binary hypothesis the centres of the component stars are in nearly every instance separated by a distance smaller than the radius of one of them—a result which renders the hypothesis untenable. It was also found that the difficulties presented by the maintenance of the oscillations on the pulsatory hypothesis are in part removed by the opacity of the stars, which must render the vibrations throughout the greater part of the interior nearly adiabatic, so that the stars are largely heat-tight. Adopting, then, the pulsation theory in Part II., Eddington investigates the rate at which the oscillations must decay in consequence of thermal dissipation; and, taking δ *Cephei* as the typical star, he finds that at the present rate the energy of the pulsation would last for 1500 years, the dissipated amount being only the $\frac{1}{200}$ part of the total outflow of heat from the star. The variations, therefore, might continue for some centuries without any very perceptible change. It is, however, pointed out that only one cause of dissipation is here discussed, and that the result obtained must not be taken as meaning more than that one of the chief objections urged against the pulsatory theory is not so serious as was at first supposed. Considering the conditions necessary for Cepheid variation, Eddington finds that it is only possible during a strictly limited stage in a star's development, but the suggestion that it may occur in all stars at the time when the central temperature reaches a certain value is not confirmed. It seems probable that Cepheid variation depends on the conditions in a star's outer layers.

A further contribution to the problem of the Cepheid variables is made by C. D. Perrine from another point of view (*Ap. J.*, **50**, 8). Emphasis is laid on the regularity of the variations, which it is considered difficult to reconcile with the pulsation theory, and the view is advanced very strongly that, despite certain small deviations from absolute uniformity, the facts are best satisfied by the hypothesis that these stars are binaries. Various points bearing on the problem are discussed with considerable fulness in the paper. For example, taking the 16 stars for which orbits have been computed on the binary hypothesis, attention is drawn to the fact that in many cases there is a well-defined recovery of light after maximum is passed, forming a "hump" in the curve, and further, that when the stars are arranged in order of the ratios of the masses of the components $\left(\frac{m^3 \sin^3 c}{m+m_1^2}\right)$, it is seen that if the ratios are less than 0·0023, no "humps" are perceptible, whereas when the ratios reach or exceed 0·0028 they become a striking feature of the curve. In other words, it is the larger secondaries which produce the "humps."

As regards the explanation of the variability of the Cepheids, the theory of R. H. Curtiss is held to be the more plausible, viz. that in which a resisting medium enhances the advancing face of the primary: in other words, Cepheid variation depends on "the difference between the two components of unequal size of a binary system revolving in a resisting medium plus the increased

activity of the secondary due to its higher orbital velocity, especially at periastron."

The binary hypothesis is also supported by J. G. Hagen (*Ast. Nach.*, 4995), but he believes the change in light to be due to outbursts caused by the close approach of a small companion at periastron.

On the other hand, F. K. Bottlinger (*Ast. Nach.*, 5019), in a discussion of existing theories, suggests as a probable cause of the variation a certain distribution of spots on the surface of a single body. He considers that the pulsation theory, though lending itself best to mathematical treatment, demands some improbable assumptions, and does not explain all the facts. It may be mentioned that Bottlinger's suggestion is in accord with the experimental light curves obtained by P. Guthnic from observations of rotating spheres with irregular surface brightness, and described by him in *Ast. Nach.*, 4993.

The question of the shortening of the period of δ *Cephei* is discussed by E. Hertzsprung in *Ast. Nach.*, 5018. He has reduced afresh J. F. J. Schmidt's observations between 1848 and 1879, and compared them with those of other observers from 1785 (Goodricke) to 1911 (Hornig). He finds that there may be a shortening of the period by $0^s{\cdot}079 \pm 0^s{\cdot}0013$ annually, but its reality depends on the reliability of the earlier observers. In a letter to the *Observatory* (**543**, 338), A. S. Eddington, referring to Hertzsprung's results (which had been forwarded to him), remarks that the evidence quite excludes the change of about 40 seconds annually demanded by the contraction theory of a star's energy, and concludes that unless we can put up with the incongruities of the binary hypothesis it seems that the energy radiated by a star must come from some other source.

Some further discussion by Eddington, Evershed, Adams, and Shapley has taken place in the *Observatory* (Nos. 537 and 538; see also No. **533**, 435) with reference to the character of the dark lines in the spectra of the Cepheid variables, which, according to the pulsation theory, should be unsymmetrically widened.

Some measures of the lines on photographs taken at the Mount Wilson Observatory are quoted as showing a widening of the lines at minimum, but the changes are symmetrical, and the displacements seem to be bodily ones. It is, however, pointed out by Shapley, that on the assumption of a darkening at the star's limb, the effect looked for would probably be inconspicuous, and his conclusion is that neither the observed shift of the lines nor their narrowness is opposed to the pulsation-hypothesis, though the theory requires a slight asymmetry which has not hitherto been observed.

H. Ludendorf (*Ast. Nach.*, 5006) has published the results of a statistical investigation relating to the Cepheid variables, together with those of the Antalgol and ζ Geminorum types. His conclusions are:—

(1) That among the stars with periods ranging from one to

thirty days, those for which the quantity $(M - m)/P$ is greater than 0·38 may have any period within the limits mentioned, whereas if the value be less than 0·38 the number of stars of any period falls off as the quantity diminishes, and that certain periods are entirely unrepresented.

(2) That, as regards the distribution of the stars, if the periods are more than two days, the range in galactic latitude and the mean galactic latitude are greater the larger the value of $(M - m)/P$, whereas if the period be less than two days the mean galactic latitude and the range in distribution depend on the maximum brightness and vary inversely with it.

Attention is drawn by C. Martin and H. C. Plummer in a paper on the short-period variable Y *Lacertæ* (*M.N.*, **80**, 33), to the fact that it is difficult to get the same range in the phases of the second harmonics of the curves of the isolated short-period variables as in those of the cluster variables, and the suggestion is made that possibly these isolated stars should be considered as forming another class with the characteristic

$$\phi_2 = \text{constant}.$$

Considering, however, that some stars showing the same range in ϕ_2 as the long-period and cluster variables have been found (*M.N.*, **78**, 186), the suggested new class seems at present uncertain.

It may be remarked here that the existence of a similar phase relation between stars of all periods by linking up the Cepheids with the cluster and long-period variables of Group II. seems to create a strong presumption against the binary interpretation of Cepheid variation. No one supposes the light changes of the long-period stars to be associated with orbital motion, and it seems that, whatever the cause of such variation, the same must be operative in producing the light changes in stars of short period also.

In this connection attention may be called to the suggestion by J. H. Jeans (*Observatory*, **536**, 88) that the variation shown both by the Cepheids and the long-period variables is due to explosions or tidal eruptions on a single rotating body. On this hypothesis the light-period of the star is the period of the explosion, this being the same as the period of rotation in the case of Group I. stars, and half of this for the Cepheids and Group II. stars.

But it will probably be felt that this theory is difficult to accept in view of the sudden "jumps" in the periods of many long-period variables which H. H. Turner has recently described.

Cluster Variables.—H. C. Plummer has contributed a valuable paper to *M.N.*, **79**, 639, on the analysis of the light-curves of variable stars in the four clusters ω *Centauri*, M3, M5, and M15. In these clusters the variables have been divided by Bailey into the sub-classes *a*, *b*, and *c*, the *a* stars exhibiting a more marked tendency towards a prolonged stationary phase at maximum, together with a larger range and shorter period than the *b* stars,

while those denoted by *c* have curves which are very nearly pure sine curves.

The proportionate numbers of the stars vary in the different clusters—*e.g.* the *c* stars constitute 50 and 35 per cent. of the variables in M15 and *ω Centauri* respectively, while they are not found at all in M3. As regards the analysis of the curves, the *a* and *b* stars are indistinguishable so far as the first three harmonics are concerned, and they agree in showing a similar phase relation to that exhibited by the long-period variables in Group II. The agreement, however, is not exact, since, putting the equation of the phases in the form

$$\phi_2 - 0{\cdot}6\phi = \text{constant},$$

we have 90° and 76° as the values of the constant in the two cases. But the two lines are closely parallel, though not coincident.

As regards the *c* stars, the suggestion is at first put forward that they may be spectroscopic binaries; but it is subsequently abandoned in view of the circumstance that the phases of the second and third harmonics tend to cluster about the lower end (90°, 0°) of the lines in the ϕ_2, ϕ_3 diagrams.

Miscellaneous Papers.—In *Ap. J.*, **50**, No. 3, F. C. Jordan deals with the difficulties introduced in the colour changes of variable stars. It is a well-known fact that long-period variables become redder as they decrease in brightness, and the determination of the colour changes, or the colour index of the stars at different parts of their light curves, is a matter of considerable importance. In this work the usual visual observation of magnitude can now be replaced by purely photographic methods, a visual luminosity filter being used in conjunction with properly sensitised plates. From a comparison with the eye estimates of competent observers, it is found that the magnitudes of stars of all colours obtained by this method are on a *visual* scale, so that the expression "photo-visual magnitudes" can be fairly used of such results.

In this paper the method of determining the colour index by a comparison of the magnitudes thus obtained with the ordinary photographic magnitudes has been applied to four short-period variables, including δ *Cephei*. One star with a spectrum of the first type is selected in each field, its magnitude assumed, and the magnitudes of all the comparison stars derived from it. The result of the investigation is to show that in each case the photographic range is greater than the photo-visual. The stars, therefore, become redder as they fade, in agreement with the behaviour of the long-period variables.

A preliminary note on "The Application of Photo-electric Photometry to Astronomy," by A. F. and F. A. Lindemann, is published in *M.N.*, **79**, 343. It contains a description in much detail of the method adopted in the preparation of photo-electric cells for astronomical purposes, together with experimental results of their application to various problems, including the determina-

tion of stellar magnitudes and temperatures. These results give great promise for the future development of this method of research.

T. E. R. P.

Double Stars.

New Pairs and Measures.—During the year 1919 particulars of 104 new double stars of less than 5″ separation have been published.

W. S. Franks (*M.N.*, **79**, 83) gives the measures of 480 miscellaneous pairs made with a $6\frac{1}{8}$-inch refractor. The separation of all pairs is over 5″, and for most pairs it is over 10″.

T. E. Espin (*M.N.*, **79**, 211) publishes the measures of 47 double stars from the Σ, *h*, Es and other lists, as well as the measures of 63 new pairs (Es 1706–1768) discovered by himself, and 71 new pairs (Milburn 36–106) discovered by W. Milburn. Of the new stars 42 in the first list and 37 in the second have a separation under 5″. The measures were all made with the 24-inch Calver reflector.

T. E. R. Phillips (*M.N.*, **79**, 509) has measured 32 well-known Σ and OΣ pairs on several nights with an 8-inch refractor. The observations of ξ Böotis and 70 Ophiuchi were made on 20 nights.

Twenty-four new pairs (ρ 115–138) were found by E. D. Roe, jr. (*A.J.*, No. 745), with a $6\frac{1}{2}$-inch and 24-inch refractor. For 13 of these pairs the separation is under 5″, but the stars are rather faint. The same observer gives (*A.J.*, No. 748) the measure of 37 old pairs.

F. P. Leavenworth (*A.J.*, Nos. 749, 750) publishes the measures of 109 double stars made with the $10\frac{1}{2}$-inch refractor of the University of Minnesota in the years 1914–19. The stars are all either well-known binaries or recently discovered doubles. For important pairs the measures were made on many nights, *e.g.* Σ 333 on 11 nights, Σ 186, Σ 2525 on 10 nights. In *A.J.*, No. 761, he also gives the measures of 60 double stars measured in 1919 with the 40-inch and 12-inch telescopes of the Yerkes Observatory.

R. Jonckheere (*A.J.*, No. 753) gives the measures of 137 stars of his catalogue and of 11 new pairs (J 1320–1330), for all of which the separation is under 5″. The observations were made with the 28-inch refractor of Greenwich Observatory.

E. E. Barnard (*A.J.*, No. 751) observed Sirius with the 40-inch telescope at Yerkes Observatory on 8 nights 1917–18, and on 15 nights 1918–19.

L. Ambronn (*A.N.*, **208**, 333) measured 75 wide double stars from Σ and Σ (App) with the heliometers of Göttingen on many nights from 1889 to 1900. The measures are discussed from the point of view of systematic differences found when the line joining the components is brought into an apparent horizontal or vertical line by means of a reversion prism.

E. Hertzsprung (*A.N.*, **208**, 115) continues his work on the

photography of double stars. The measures obtained on 143 plates for 36 Σ stars, several of which are well-known binaries, are given. The closest pair measured is Σ 1785, with a separation of 1″·12. This pair was only regarded as experimental, for other 5 pairs the separation is under 2″, and for 35 pairs the separation is between 2″ and 5″. The probable errors are small. The author's purpose in these measures is to try to find double stars in which there is a departure from Keplerian motion (see ξ Ursæ Majoris, below).

In the summary of the twenty-third meeting of the American Astronomical Society (*Pop. Ast.*, 27, 664), C. P. Olivier gives a note on the result of measures of double stars on parallax plates. The actual measures are soon to appear in the publications of the Leander M'Cormick Observatory. Over 80 double stars have been measured on a scale of 1 mm. = 20″·8. The conclusion reached is that "with the M'Cormick 26-inch telescope, if plates are taken under good conditions of seeing, the average doubles down to 2″ separation can be photographed and accurately measured. For more favourable cases the limit can be put at 1″·5 or even a trifle lower." 70 Ophiuchi and Krüger 60 have been photographed at several epochs. These results obtained by Hertzsprung and Olivier indicate a real advance in the photography of double stars, although for the really close double stars visual measures alone are possible.

F. C. Leonard (*Pop. Ast.*, 27, 633) gives measures of a new double star. E. Doolittle (*M.N.*, 79, 511 and 657) gives notes on Espin's and Jonckheere's latest pairs.

Double Stars showing Relative Motion.—During 1919 orbits have been published for γ Lupi and β 1111.

Bernard H. Dawson (*A.J.*, No. 758) gives measures and orbit for γ Lupi. This is a binary in which the orbit passes nearly through the line of sight. The period found is 104·3 years and the semi-major axis 0″·78.

R. G. Aitken (*Publ. A.S.P.*, 31, 285) gives a fairly well determined orbit for β 1111. The period is 40·53 years and the semi-major axis 0″·235. On p. 197 of the same volume he discusses the triple system of which AB is A 2131, and AC is Ho 357. He finds that C is only an optical member of the system, while the close pair are in rapid orbital motion (5° per year at 0″·30) and have the large proper motion of 0″·44 annually. This system is probably near our own and should be observed for parallax.

E. Doolittle (*Publ. A.S.P.*, 31, 275) finds that the observations of Hu 321 can be explained by a relative proper motion of 0″·144 annually. This is large for such faint stars. The same writer (*A.J.*, No. 746) discusses the motions of Σ 208 and Σ 1834. The first of these pairs shows accelerated motion and the second a possible slight curvature. In both cases, however, the motion has been practically rectilinear with the faint star moving towards the brighter. These pairs should be carefully observed with large refractors, and in fact Aitken (*Publ. A.S.P.*, 31, 116) gives measures for 1914–16 which confirm the orbital motion.

J. S. Plaskett (*Publ. A.S.P.*, 31, 39) finds that the components

of Σ 3050 have radial velocities differing by 2·8 km. per sec. This, together with the closeness and brightness of the pair, leads him to conclude that it is a true binary. E. Doolittle (p. 158) examines the micrometric measures of over ninety years and finds that the measures are still well represented by rectilinear motion, although the pair might well be binary.

R. G. Aitken (*Publ. A.S.P.*, **31**, 44) gives a list of 17 double stars discovered by himself which already show large angular motion. This is in addition to previous lists. The separation is in most cases under 0″·3. It is desirable that these stars should be measured for parallax.

E. Hertzsprung (*A.N.*, **208**, 111) gives the results of the measures of ξ Ursæ Majoris on 38 plates (2156 exposures), taken during the period 1914–18. His results confirm the conclusion of N. E. Nörlund (*A.N.*, **170**, 117) that there is a perturbation of 1·8 year period. W. H. Wright has previously shown (*Ap. J.*, **12**, 254) that the principal star was a spectroscopic binary of this period. Hertzsprung concludes that the perturbation might be caused by a third body revolving in an orbit passing nearly through the line of sight, but decides against the probability of eclipse taking place.

General Remarks.—The outstanding feature of double-star astronomy in 1919 has been the appearance of R. G. Aitken's book, *The Binary Stars*. This work should prove of the greatest use to students of double stars as the best text-book we have on the subject; it is also an important addition to the literature of stellar astronomy. It is specially fitting that the book has come from the man who, more than any other, has helped to place on a sure basis our knowledge of the significance of visual double stars in the sidereal system. The book marks the completion (in 1915) of Aitken's great survey of the heavens for double stars begun in 1899, extending from the north pole to −14° Dec. for 12 hours of R.A. and to −22° Dec. for the other 12 hours, and including all stars as bright as $9^{m}\cdot0$ on the B.D. scale. We here draw special attention to Chapters VIII. and X. In the first of these the correlations existing amongst the elements of known orbits and the spectral type are dealt with, in the second there is a statistical study of the distribution of 5400 visual double stars, of which the spectra of 3919 are known. In these two chapters some results previously announced by various investigators are verified with the larger amount of material now available; other results are now given for the first time. At the end of the book are tables giving the elements of all reliable orbits so far computed. There are 87 visual and 137 spectroscopic systems. These tables will probably be freely used in future researches, and in fact have been already used by several investigators.

It has been well known for some time that the masses of binary systems are on the average of the order of twice the sun's mass. This fact can be used with considerable confidence for estimating the probable parallax of such systems. It is of the

utmost importance that the accuracy of this result should be tested with all the means available. Aitken in his book discusses the results, using only the trigonometric parallaxes for visual doubles and deducing the mean mass of the spectroscopic systems by applying a factor to allow for the unknown inclination of the orbit plane. For the 14 visual systems for which the required data are available he deduced a mean mass of 1·76 times that of the sun. For spectroscopic systems the masses are greater and for the B type stars (unrepresented in the visual systems) much greater. The mean mass for 9 B type spectroscopic binaries is 20·8. The publication by Adams and Joy of 500 parallaxes deduced by Adams's spectroscopic method allows of the determination of the masses of some additional masses for visual binaries. The subject is taken up by Aitken (*Publ. A.S.P.*, 31, 196) and by A. van Maanen and R. F. Sanford (*ibid.*, p. 231). The previous mean results are fairly confirmed, although there is rather a large range in the individual determinations. Aitken, from the trigonometric parallaxes, found a range (unit equal to the mass of the sun) from 0·45 for Krueger 60 to 3·3 for ϵ Hydræ. With the spectroscopic parallaxes applied to the same stars he finds a range from 0·21 for ϵ Hydræ to 7·21 for ζ Herculis. For the 7 new systems he finds a mean mass of 2·01, and for the total of 21 systems a mean mass of 1·88. Van Maanen and Sanford discuss the masses of 39 systems, using all parallaxes available, including unpublished spectroscopic parallaxes. Two systems are rejected because the masses are excessive. The larger of these is 45·7 for β Delphini. For the same system Aitken found a mass of only 2·81. The difference is due to the different parallaxes used, $''$·015 and $''$·038 respectively. These results indicate the errors to which we are still liable in the determination of stellar masses. A warning must be given against the too hasty conclusion that the masses of all binary systems may be taken as twice the sun's mass. From the periods and semi-axes of the 87 known systems it follows that either the masses are much greater than this value, or that they are comparatively near to our own system. Van Maanen and Sanford find a correlation between the masses and the absolute magnitudes, and also an indication that the larger velocities belong to stars with small mean masses. If the increase of mass with luminosity is confirmed, Aitken's result (*Binary Stars*, p. 262), that the bright stars have a larger percentage of doubles, may become of importance in connection with theories on the origin of binary systems.

The evolution of binary stars is discussed by J. H. Jeans (*M.N.*, 79, 100 and 408). In the earlier of these papers he concludes that the binary stars were formed by fission, and that the only possible dynamical explanation of the visual systems as they are at this time is that the present epoch was preceded by one in which the stars were more closely packed than they are now, so that stellar encounters at fairly close distances were events of comparatively common occurrence. In the second paper the result

of a long series of encounters is discussed. It is concluded that the spectroscopic binaries may have recently evolved by fission. While some of the visual binaries may have been formed in the manner given in the first paper, the possibility of the origin of the components in separate nuclei of an original nebula is not denied.

H. E. Lau (*A.N.*, 208, 179) treats of the difference in colour of the components of double stars. He finds that for stars of early type the fainter star is the redder, and in later types the brighter star is the redder. The components have the same colour when the spectral type is about F5. Here spectral type means type of the brighter component. The connection between proper motion and spectral type is also considered.

The question of the nature of star discs when the telescope is suffering from various imperfections is treated theoretically by A. E. Conrady (*M.N.*, 79, 575). Aitken, in his book, gives many interesting remarks of a practical kind on the resolving power of telescopes: the result of long experience with the 36-inch Lick refractor. In a review of Aitken's book (*Publ. A.S.P.*, 31, 170), E. E. Barnard gives further notes based on his own experience.

J. J.

Stellar Spectroscopy in 1919.

Nebulæ.—Two nebulæ, N.G.C. 4449, 4214, have been found by V. M. Slipher to have unusual spectra. They have a continuous spectrum crossed by strong emission lines typical of gaseous nebulæ. The nebula N.G.C. 4449 is receding from the solar system with a velocity of about 200 km./sec., the nebula N.G.C. 4214 with a velocity of about 300 km./sec., implying that they are affiliated with the spiral family (*A.S.P.*, 30, 346).

The "Crab" nebula, N.G.C. 1952, examined by R. F. Sanford, exhibits similar peculiarities. Some of the emission lines show discordant displacements: some indicating a velocity of 600 km./sec. of approach, and others, on equally plausible assignment of origin, give velocities of 1620 and 1750 km./sec. of recession (*A.S.P.*, 31, 108).

The Orion nebulosities lying within the large wisp of outer nebula starting near γ Orionis and sweeping round within κ and β towards the Great Nebula near θ, first photographed by W. H. Pickering in 1889 (see also Barnard, *Ap. J.*, 7, 77), have been made the subject of study by V. M. Slipher, who has compared the spectrum of the trapezium in the Great Nebula with those of N.G.C. 1982, 1977, and 2068, named in the order of their distances from θ. Slipher finds signs of a gradual change in the series, from an emission spectrum to a continuous spectrum of B-type (*A.S.P.*, 31, 212).

The distribution of luminosity in the Great Nebula in Orion has been investigated anew by J. H. Reynolds, on the lines of the earlier work of Keeler and Hartmann. He compares the photographs of the nebula obtained through screens suited for eliminating

the light of various elements, and infers that nebulium is confined chiefly to the Huyghenian region and its neighbourhood. Hydrogen extends further out, and the element responsible for the bright emission at λ 3727 is more prominent in the outer regions (*M.N.*, 79, 561).

Novæ. Nova Aquilæ III.—Exceedingly interesting notes on spectral peculiarities of Nova Aquilæ III. in 1919 July are published by W. H. Wright and by J. H. Moore and C. D. Shane. The Lick observers have found that the light distributed in different parts of each of the broad and complex emission lines of the Nova comes from different parts of the disc of the Nova. Barnard has discovered (*Ap. J.*, 49, 199), in the autumn of 1918 (*N.B.* misprinted as 1919 on p. 200), that the Nova exhibited a small planetary disc of diameter ranging from 0″·81 on October 5 to 1″·86 on December 17. The Lick observers examined the spectrum of the disc in 1919 July, placing the slit of the spectrograph in different position angles on the disc, and they are to be congratulated on having made a very important discovery, which is likely to contribute largely to the understanding of the phenomena of Novæ (*L.O.B.*, 10, 30).

Several communications relating to the spectrum of Nova Aquilæ III. have appeared during the year. J. Evershed (*M.N.*, 79, 468), dealing with observations made at Kodaikánal, between June 12 and 23, gives measures of the absorption and emission lines of hydrogen, of the calcium lines H and K, of the iron lines, and of the absorption band at 4055–4067; and concludes that the hydrogen lines indicate increasing velocities of gases driven out from the Nova, and compares the motions with those recognised in the sun's surroundings.

Father Cortie contributes four notes:

1. *M.N.*, 79, 121: dark and bright lines on June 10; comparison with α Cygni.
2. „ „ 171: measures on June 15.
3. „ „ 491: measures on July 19; oxygen and nitrogen lines.
4. „ „ 555: measures on July 29, August 23, September 25, October 4 and 23.

C. P. Butler gives a fuller account of the changes, noted in the earliest days of the outburst, in the ultra-violet portion of the spectrum (*M.N.*, 79, 498).

J. Lunt deals with the dark-line spectrum on June 11 and 12, and gives full tables of lines measured (*M.N.*, 79, 419).

J. S. Plaskett gives a brief note and reproductions of the spectra obtained at Victoria on eleven nights between June 10 and August 5 (*R.A.S. Can.*, 1918 September).

G. F. Paddock contributes notes on the yellow-red region of the spectrum photographed at Mount Hamilton on 51 dates between June 14 and October 14 (*A.S.P.*, 31, 47). He also

calls attention to four absorption lines in the blue region (*A.S.P.*, **31**, 55).

F. E. Baxandall gives reason for identifying two of Paddock's lines with somewhat abnormal nitrogen lines (*A.S.P.*, **31**, 297).

M. Humason records observations of the magnitude of the Nova, in continuation of the Harvard light curve up to July 17, between the dates 1918 July 17 and November.

Nova Geminorum II.—F. J. M. Stratton, in a preliminary note, records his important discovery that in Nova Geminorum II. when the enhanced metallic lines characteristic of α Cygni are dying out, many of the surviving lines are best summarised as a γ Orionis spectrum displaced, with non-metallic elements prominent, such as oxygen, helium, and nitrogen. This identification throws a new light also on the interpretation of the spectrum of Nova Aquilæ III. (*M.N.*, **79**, 366).

J. Lunt (*M.N.*, **79**, 130), in a paper on the dark-line spectrum of Nova Geminorum No. 2, corroborates the view presented by Newall and Stratton in an earlier paper (*M.N.*, **73**, 380).

Nova Ophiuchi.—The *Harvard Bulletin*, No. 696, announces the discovery of a Nova in Ophiuchus by Miss Mackie.

W. S. Adams and A. H. Joy succeeded in obtaining spectrograms at Mount Wilson of this 9th magnitude star, and found the spectrum similar in general features to that of Nova Aquilæ III. in its earliest stages (*A.S.P.*, **31**, 307).

W. H. Wright was also successful at Mount Hamilton in photographing the spectrum (*A.S.P.*, **31**, 314).

Nova Sagittæ.—The *Harvard Circular*, No. 219, announces the discovery of a Nova in Sagitta by Miss Mackie; its outburst occurred in 1913 November, and it was then of magnitude 7·2, but has since faded to magnitude 14·5.

W. H. Wright reports that two spectrograms were secured by Dr Curtis with the Crossley Reflector (*A.S.P.*, **31**, 313).

Nova Serpentis.—H. Shapley records observations of the star designated Serpentis 7·1917, independently noted by M. Wolf and E. E. Barnard. The star seems to have become visible between 1908 June and 1909 July (*A.S.P.*, **31**, 226).

In a note on the absorption spectrum of the Novæ, W. S. Adams calls attention to the appearance of a harmonic relationship between the displacements of the components of the hydrogen lines in many Novæ (*N. Acad. W.*, **4**, 355).

C. O. Lampland reports that Nova Persei 1901 still shows signs of variation in magnitude, with a change from 13·5 in 1918 March to about 12·5 in 1918 September–November (*A.S.P.*, **30**, 347).

Special Studies.—Attention having been called by F. E. Baxandall to a possible variation in the bright lines of η Carinæ (Argûs), the spectrum has been successfully photographed by J. Lunt (*M.N.*, **79**, 619 and 621).

The discovery, by P. W. Merrill, of bright nebular lines in the

spectrum of the long-period variable star R Aquarii is one of great interest, as bearing upon H. N. Russell's suggestion as to the possible order of evolution of stars (*A.S.P.*, **31**, 305). The observation is confirmed by J. H. Moore, and commented on by W. H. Wright (*A.S.P.*, **31**, 309).

Of the 76 stars which the Harvard observers have recorded as having composite spectra, the Lick observers have examined 37 in search of signs of variable radial velocities; and have found that 23 give positive results, 6 doubtful, and 8 negative. In a brief note recording these results, W. W. Campbell recalls that the term "composite" has been applied only to the combination of spectra of very different types (*A.S.P.*, **31**, 37).

The anomalous behaviour of the H and K lines in the spectra of spectroscopic binaries has often been noted. The behaviour of the D lines of sodium is found by M. L. Meger to be in agreement with that of the H and K lines in the spectra of β Scorpii and δ Orionis (*L.O.B.*, **10**, 59).

Between 1500 and 1600 stars have been now examined at Mount Wilson by the spectroscopic method of determining parallax; and in a very interesting summary W. S. Adams and G. Strömberg discuss the application of the method to stars of high luminosity and small parallax (*N. Acad. W.*, **5**, 228).

A note on progressive change of wave-lengths of lines in stellar spectra with change of type is given by S. Albrecht (*Ap. J.*, **50**, 277).

In an interesting note on the green auroral line, V. M. Slipher raises the question whether the aurora does not contribute an appreciable part of the total light of the sky. C. Fabry joins in the discussion (*Ap. J.*, **49**, 266, and **50**, 308).

Classification.—The publication of the first volume of the new Henry Draper Catalogue was not noted in last year's report, by an oversight which it is difficult to understand. It was issued in the autumn of 1918, and marked the first step in the last stage of a piece of work of colossal magnitude, carried out with all the precision of masterly organisation. Thirty years ago the Draper Catalogue of the spectra of 10498 stars seemed a huge undertaking, successfully accomplished by Professor E. C. Pickering; but it is altogether dwarfed by the new Henry Draper Catalogue, which will contain a specification of the type of spectrum of more than 20 times the number of stars, in a classification approximately 10 times as detailed as that adopted in the earlier work. The second volume was distributed in the autumn of 1919, and contains the stars from pole to pole in the range of R.A. $4^h\ 0^m{\cdot}0$ to $6^h\ 59^m{\cdot}9$. Miss Cannon and her devoted assistants have fulfilled the expectation which Professor Pickering expressed in his preface to the first volume under the date 1917 December 13; and the whole work is finished, except for the printing, in 1920 January. Miss Cannon's work, carried out with unfailing enthusiasm, has included the classification, the revision, and the supervision of the

whole. It has involved six years of very strenuous application on her part, with the aid of several assistants, the average number being five. The title-pages of both volumes bear the names of Annie J. Cannon and Edward C. Pickering, as joint authors; and in congratulating Miss Cannon on the completion of her task, we would express our deep regret that her stimulating collaborator has not lived to receive our renewed homage on the completion of this great work.

In the *Hill Observatory Bulletin*, No. 6, Sir Norman Lockyer continues his notes on Stellar Classification, and summarises the results of more recent work at Salcombe Regis, in relation to a new catalogue of 287 stars.

Variable Stars.—The spectra of SX Cassiopeiæ (period $36^d{\cdot}5$) and RX Cassiopeiæ (period $32^d{\cdot}3$) have been photographed at Mount Wilson by W. S. Adams and A. H. Joy. SX Cassiopeiæ is found to show only one component, and five plates testify to a range of velocity of about 75 km./sec. The spectrum is similar to that of α Cygni. RX Cassiopeiæ also shows only one component and a range of 11 km./sec. from maximum to minimum of light. The hydrogen lines are bright with the centres reversed; otherwise the type is G3 (*A.S.P.*, **31**, 308).

The spectrum of *o* Ceti has been photographed during the recent maximum by C. D. Shane, in the spectral region 4800–6700. Irregularities in the displacements of the bright H_α and H_β lines are detected (*A.S.P.*, **31**, 318).

Irregularities in the occurrence of bright edges of the star Boss 5918 are recorded by E. B. Frost. The star, of type B3, has been shown by J. S. Plaskett to have variable radial velocity (*Ap. J.*, **49**, 61).

A second paper on the cause of Cepheid variation is published by C. D. Perrine (*Ap. J.*, **50**, 81), together with a note on the residual radial velocities of Cepheid variable stars in relation to the pulsation theory (*Ap. J.*, **50**, 148).

Radial Velocity.—The motions in space of 37 stars of high velocity are discussed by W. S. Adams and A. H. Joy, who find that the components of velocity normal to the plane of the galaxy are in the average less than a half as large as those in the plane; the apices of the stars' ways are all included in little more than one galactic hemisphere (longitudes 131° to 320°); 28 stars of low luminosity ($M = 5{\cdot}9$) have their apices lying more nearly in the plane of the galaxy than the 9 stars of high luminosity ($M = +0{\cdot}4$), and they have velocities (average, 216 km./sec) nearly twice as great; the stars of type F have velocities nearly twice as great as stars of type G (*Ap. J.*, **49**, 179).

A list of radial velocities of 185 stars observed at the Cape is given by J. Lunt; of these 42 relate to stars north of the equator. The list is divided into two parts, separating stars (122) which seem to have fairly constant velocities from those (63) which are possibly variable in velocity (*Ap. J.*, **50**, 161).

Two lists of measures of radial velocity of 14 and 5 stars are published by J. B. Cannon of the Ottawa Observatory. Several of these stars show signs of variable velocity (*Ott.* **4**, 31, and 254).

Variable Radial Velocity.—A slow change in the radial velocity of the brighter component of the double star β Cygni is noted by W. W. Campbell, from observations on 25 nights between 1898 and 1918:—

1898–1901	−25·3 km./sec.	5 nights
1904–07	−24·4 ,,	2 ,,
1910–12	−23·2 ,,	6 ,,
1913–14	−23·0 ,,	6 ,,
1917–18	−21·6 ,,	6 ,,

The Harvard observers describe the spectrum as "composite" (*A.S.P.*, **31**, 38).

A list of 14 stars which show variations in the radial velocity is given by W. S. Adams and A. H. Joy (*A.S.P.*, **31**, 40).

The first list of 12 stars with variable velocity discovered at the Astrophysical Observatory, Victoria, B.C., is given by J. S. Plaskett (*R.A.S. Can.*, Nov. 1918). It includes 9 stars of type A and 3 of type B2–5.

Spectroscopic Binary Stars.—Orbits are given for the following stars:—

					P.	*e.*
δ Columbæ	G5	Wilson & Huffer	*L.O.B.*,	10, 15	870^d	0·76
A Carinæ	G5	,, ,,	,,	10, 17	195·32	0·0
Boss 593	F4–5	Adams & Joy	*Ap. J.*,	49, 186	9·851	0·16
W Ursæ Majoris	F8p	,,	,,	49, 189	0·334	0·0
Z Herculis	F2	,,	,,	49, 192	3·993	0·0
Boss 3511	F	Harper	*Ott.*,	4, 223	1·611	0·05
Boss 2484	A2	,,	,,	3, 392	15·986	0·50
Boss 5173	A	,,	,,	4, 199	9·316	0·012
19 Lyncis	B8	,,	,,	4, 235	2·26	0·08
h Draconis	F5	,,	,,	4, 244	51·71	0·15
20 π Cassiopeiæ	A5	,,	,,	4, 135	1·964	0·01
29 Canis Majoris	Oe	,,	,,	4, 115	4·393	0·16
125 Tauri	B3	Cannon	,,	3, 409	27·864	0·55
32 θ_2 Cygni	G5	,,	,,	4, 153	1170	0·18
Boss 3138	B3	,,	,,	4, 125	1·503	0·08
Boss 1082	G5	,,	,,	4, 175	121	0·19
Boss 1275	A	,,	,,	4, 185	27·43	0·25
Boss 6142	Bp	R. K. Young	,,	3, 373	13·435	0·11
40 Aurigæ	A	,,	,,	4, 95	28·28	0·56
χ Aurigæ	B1	,,	,,	4, 1	655·16	0·17
2 Sagittæ	A3	,,	,,	4, 55	7·390	0·05
π Arietis	B5	,,	,,	4, 69	3·854	0·04
Boss 5996	A	,,	,,	4, 83	3·219	0·04

R. K. Young calls attention to the smaller range of velocities given by the calcium lines in the binary star χ Aurigæ, and gives an interesting summary of the behaviour of these lines in other stars (*Ott.*, **4**, 24).

Work in the Laboratory.—The arc spectrum of scandium has been photographed and measured by Sir W. Crookes. For the arc electrodes, pure powdered scandia and finely divided silver were compressed into rods by means of a hydraulic press. Wave-lengths are given for the region 2420–6305 (*Proc. R.S.*, **95**, 438).

The infra-red arc spectrum of iron, and of cobalt, nickel, manganese, and chromium has been studied bolometrically from λ 9000 to λ 30,000 by H. M. Randall and E. F. Barker (*Ap. J.*, **49**, 42 and 54).

The difficulty of interpreting spectral phenomena in electrically heated furnaces is discussed by A. S. King, by comparison of his results with those of G. A. Hemsalech (*Ap. J.*, **49**, 48; *Phil. Mag.*, **36**, 209, 281). Considerable light is thrown on the subject in a remarkable paper by G. A. Hemsalech, dealing with the separation, by magnetic fields, of thermo-chemical and thermo-electronic luminosity (*Phil. Mag.*, **39**, 241).

The study of metallic spectra produced in high vacua has been continued by E. Carter and A. S. King. The metals manganese, titanium, iron, magnesium, calcium, and cadmium were in turn vaporised at the focus of a beam of cathode rays; and these luminescence spectra have been compared with arc, spark, and furnace spectra (*Ap. J.*, **49**, 224).

The intensity relations in the spectrum of helium have been examined by T. R. Merton and J. W. Nicholson, with important results relating to the different series (*Phil. Trans.*, **220**, 137).

The ultra-violet band of ammonia about λ 3360 has been studied by A. Fowler and C. C. L. Gregory, with a double success, firstly, as to its structure, and secondly, as to its occurrence in the solar spectrum (*Phil. Trans.*, **218**, 351).

Instruments.—The spectrograph attached to the 72-inch reflector of the Victoria Observatory is described by J. S. Plaskett. A well-exposed spectrum of a star of photographic magnitude 7·0 can be obtained in 20 to 25 minutes (*Ap. J.*, **49**, 209).

Miscellaneous.—Father Rodés, of the Ebro Observatory, writing from Mount Wilson, contributes a note on the relation of the Doppler effect to Kirchhoff's law (*A.S.P.*, **31**, 91).

H. N. Russell raises interesting questions about the sources of stellar energy (*A.S.P.*, **31**, 205).

F. Sanford continues his study of the unit electrical charge, on the view that the Rydberg constant N is the wave-number of an electron revolving about a central positive charge $Q = 2e = 9{\cdot}548 \times 10^{-10}$ E.S.U.; and applies his calculations to the case of the six series of lines in the spectrum of helium (*Ap. J.*, **49**, 337).

T. Takamine has extended the method of J. A. Anderson for examining the Stark effect, and has studied the effect in the ten metals: Ag, Au, Co, Cu, Fe, Mg, Mn, Mo, Ni, W, and has detected the effect also in Na, O, and N (*Ap. J.*, **50**, 23).

H. F. N.

The International Astronomical Union.

The activities of the existing international scientific associations having been practically suspended during the war, the question naturally arose as to the form which such organisations should assume when peace was restored. In 1918 October and November conferences of delegates of the leading scientific academies of the allied and associated nations were successively held in London and Paris to consider the question, and it was resolved that the nations at war with the Central Powers should withdraw from the existing conventions and proceed to establish new organisations, with the eventual co-operation of neutral nations. A provisional executive committee was appointed to give effect to the resolutions adopted, and a further conference of delegates was held at Brussels during 1919 July. The countries represented were Belgium, Canada, France, Italy, Japan, New Zealand, Poland, Portugal, Roumania, Serbia, United Kingdom, and United States of America. An "International Research Council," to deal with all matters of international scientific interest, was then formally constituted, with Professor E. Picard as president, Sir Arthur Schuster as secretary, and Professors Hale, Lecointe, and Volterra as other members of the executive committee.

The immediate formation of international unions for astronomy and geophysics had been decided upon at the earlier conferences, and statutes for these organisations had been drafted in advance by committees which had been appointed for the purpose by the Council of the Royal Society and by the Paris Academy of Sciences. At the Brussels conference these unions were formally constituted, and the statutes adopted with some modifications of detail. The formation of unions for other departments of science was also taken into consideration, but arrangements for these were not completed.

The delegates representing Astronomy were as follows:—

Belgium.—De Donder, Delporte, Delvosal, Lecointe, Philippot, Stroobant, Van Biesbroeck.

France.—Andoyer, Baillaud, Bigourdan, de la Baume Pluvinel, Deslandres, Ferrié, Hamy.

Italy.—Palazzo, Riccò.

Japan.—Tanakadate.

United Kingdom.—Cowell, Dyson, Fowler, Glaisher, Newall, Sampson, Turner.

United States.—Adams, Boss, Campbell, Fox, S. A. Mitchell, St. John, Schlesinger, Seares, Stebbins.

The purpose of the International Astronomical Union, as defined by the statutes of the convention, is: (1) To facilitate the relations between astronomers of different countries where international co-operation is necessary or useful; (2) to promote the study of astronomy in all its departments.

It is provided that in each of the countries adhering to the Union, a National Committee shall be formed for the promotion and co-ordination of astronomical work in relation to international requirements, and for the nomination of delegates to represent them at the meetings of the Union. On the initiative of the Royal Society, such a National Committee has already been formed in this country, consisting of the Astronomers Royal of England, Scotland, and Ireland, the Superintendent of the *Nautical Almanac;* six members appointed by the Royal Society, six by the Royal Astronomical Society, two by the Royal Society of Edinburgh, two by the Royal Irish Academy, and two by the British Astronomical Association. Similar National Committees have also been constituted in the United States and in France. All members of National Committees, and other individuals who may be invited by the President of the Union, may attend the meetings and take part in the discussions of the General Assembly, but without power of voting.

At the Brussels conference it was decided, after much discussion, that the work of the International Astronomical Union could best be carried on through a number of committees dealing with different branches of astronomy, together with an executive committee for general purposes of administration. M. B. Baillaud, Director of the Paris Observatory, was elected first President of the Union; with Sir Frank Dyson, Professor W. W. Campbell, Professor G. Lecointe, and Professor A. Riccò as Vice-Presidents; and Professor A. Fowler as General Secretary of the Executive Committee. Professor Antonio Abetti has since been elected to fill the vacancy caused by the death of Professor Riccò.

Thirty-two working committees, each having its own president, were appointed to continue the work of the older associations and to promote co-operation in other branches of astronomy. Under the statutes, the presidents and members of these committees are to be elected by the General Assembly of delegates, but each committee has been given power to add to its numbers as may be considered desirable, and may draw up its own regulations or bye-laws, subject to approval by the General Assembly.

It may be pointed out that nearly one-half of the sections into which the work of the Union has thus been divided were previously included in the International Solar Union, or were the subjects of separate organisations, such as the Astrographic Chart and the service of Astronomical Telegrams. The range of subjects to be dealt with has now been extended by the formation of committees to promote co-operation in the study of Relativity, Dynamical Astronomy, Physical Observations of the Planets, Stellar Parallaxes, and so on.

The central bureau for international astronomical telegrams has been established at the Royal Observatory, Brussels; telegrams intended for the bureau should in future be addressed "Astra, Brussels." The central office of the International Time Service is at the Paris Observatory, and that of the Astrographic Chart at the University Observatory, Oxford. It is hoped that substantial advantages will result from the amalgamation of the various departments of activity under a single organisation.

Each participating country will contribute to the funds of the Union, and will have voting power on questions of administration, on a scale dependent upon its population. Self-governing Dominions, such as Canada and Australia, are entitled to join under the same conditions as independent States. By unanimous vote of the twelve countries represented at the conference, it was further resolved that all nations which had remained neutral during the war should be invited to join the International Research Council and to take part in the work of the International Unions which have been formed under its auspices.

General meetings of the Astronomical Union will be held once every three years as a rule, but not necessarily at the same time and place as the General Assembly of the Research Council or of other Unions. A. F.

LIST OF PUBLIC INSTITUTIONS AND OF PERSONS WHO HAVE CONTRIBUTED TO THE LIBRARY, ETC., SINCE THE LAST ANNIVERSARY.

His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The Crown Agents for the Colonies.
The Egyptian Government.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Conjoint Board of Scientific Societies.
Imperial College of Science and Technology.
Institution of Civil Engineers.
Institution of Electrical Engineers.
London Mathematical Society.
London, University College.
Meteorological Office.
National Physical Laboratory.
Physical Society of London.
Royal Institution of Great Britain.
Royal Observatory, Greenwich.
Royal Photographic Society of Great Britain.
Royal Society of London.
Belfast, Natural History and Philosophical Society.
Birmingham, Natural History and Philosophical Society.
Bradford, Libraries, Art Gallery and Museums Committee.
Cambridge Philosophical Society.
Cambridge, Solar Physics Observatory.
Cambridge Observatory.
Cape of Good Hope, Royal Observatory.
Chaldæan Society.
Chatham, Royal Engineers' Institute.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Edinburgh Royal Observatory.
Edinburgh, Royal Society.
Leeds Astronomical Society.
Liverpool Literary and Philosophical Society.
Manchester Literary and Philosophical Society.
Oxford, Radcliffe Observatory.
Oxford, University Observatory.
Salcombe Regis, Hill Observatory.
Stonyhurst College Observatory.
American Astronomical Society.
Arcetri, Reale Osservatorio.
Association Géodésique Internationale.

Athens, Observatoire National.
Barcelona, Observatorio Fabra.
Basel, Naturforschende Gesellschaft.
Batavia, Royal Magnetical and Meteorological Observatory.
Berlin, Astronomisches Rechen-Institut.
Berlin, Preussische Akademie der Wissenschaften.
Berlin, Preussisches Geodätisches Institut.
Berlin-Babelsberg, Sternwarte.
Berne University.
Bologna, Reale Accademia delle Scienze.
Bombay and Alibag Observatories.
Bordeaux, Société des Sciences Physiques et Naturelles.
Boston, Westwood Astrophysical Observatory.
Brussels, Académie Royale des Sciences.
Brussels, Société Belge d'Astronomie.
Calcutta, Astronomical Society of India.
Canada, Geodetic Survey.
Canada, Royal Society.
Cape Town, Royal Society of South Africa.
Cape Town, South African Association for the Advancement of Science.
Catania, Società degli Spettroscopisti Italiani.
Christiania, Norske Meteorologiske Institut.
Cincinnati Observatory.
Copenhagen, K. Danske Vidensk. Selskab.
Copenhagen, Observatorium.
Geneva, Société de Physique et d'Histoire Naturelle.
Genoa, Istituto Idrografico.
Harvard College Astronomical Observatory.
Heidelberg, Sternwarte.
Helsingfors, Finska Vetenskaps Societet.
Hobart, Royal Society of Tasmania.
Hyderabad, Nizamiah Observatory.
Illinois Observatory.
India, United Service Institution.
Japan, Astronomical Society.
Johannesburg, Union Observatory.
Kodaikánal and Madras Observatories.
La Plata, Observatorio Astronomico.
Lick Observatory.
Lisbon, Academia das Sciéncias.
Lisbon (Tapada), Observatorio Astronomico.
Lowell Observatory.
Lund, Astronomiska Observatorium.
Madrid, Observatorio Astronómico.
Madrid, Real Academia de Ciencias.
Marseille, Observatoire.
Mauritius, Royal Alfred Observatory.
Montpellier, Académie des Sciences et Lettres.
Mount Wilson, Solar Observatory.

Neuchatel, Observatoire Cantonal.
New Zealand Department of Lands and Survey.
Oporto, Academia Polytechnica.
Ottawa, Dominion Astronomical Observatory.
Paris, Académie des Sciences.
Paris, Bureau des Longitudes.
Paris, Bureau International des Poids et Mesures.
Paris, Ministère de l'Instruction Publique.
Paris, Observatoire.
Paris, Société Astronomique de France.
Paris, Société Mathématique de France.
Paris, Société Philomathique.
Perth, Western Australian Astronomical Society.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Potsdam, Central Bureau der Internationalen Erdmessung.
Rio de Janeiro, Observatorio.
Rome, Reale Accademia dei Lincei.
Rome, Real Osservatorio del Collegio Romano.
Rome, Specola Vaticana.
San Fernando, Instituto y Observatorio di Marina.
San Francisco, Astronomical Society of the Pacific.
Stockholm, Kungliga Svenska Vetensk. Akademie.
Stockholm, Observatorium.
Sydney, Royal Society of New South Wales.
Tacubaya, Observatorio Astronómico Nacional.
Tokyo, Observatoire Astronomique.
Toronto, Royal Astronomical Society of Canada.
Toronto, Royal Canadian Institute.
Tortosa, Observatorio del Ebro.
Turin, Reale Accademia delle Scienze.
Uccle, Observatoire Royal de Belgique.
Upsala, Kongliga Vetenskaps Societet.
Upsala, Observatoire Astronomique.
Washington, Carnegie Institution.
Washington, National Academy of Sciences.
Washington, Navy Department.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Wellington, New Zealand, Hector Observatory.
Yerkes Observatory.
Zurich, Naturforschende Gesellschaft.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."
Editors of the "Astrophysical Journal."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."

Editor of "Nature."
Editors of "The Observatory."
Editors of "Popular Astronomy."
Editors of "Terrestrial Magnetism."

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ADDRESS

Delivered by the President, Professor A. Fowler, F.R.S., on the occasion of the Hundredth Anniversary of the Society.

Our meeting to-day marks an important epoch in the history of the Royal Astronomical Society. It is, in fact, a hundred years since the first Annual General Meeting of the Society, and the report which has just been presented is the hundredth annual report of the Council. A fitting celebration of this event has been rendered impossible for the present by circumstances arising out of the war, but the question has become the subject of consideration by the Council, and their proposals will be announced in due course. It has been thought, nevertheless, that the occasion should not be allowed to pass by without some reference to the past, and by desire of the Council I shall take the opportunity of recalling briefly the events connected with the formation of the Society, and the ideals which were present in the minds of its founders. My task has been greatly simplified by the admirable records of the activities of the Society which are to be found in the minutes of the meetings of the Council and of the ordinary meetings, as well as in the earlier publications of the Society.

A consideration of the position of astronomy in the early years of the nineteenth century will show quite clearly that the founders of the Society were not actuated by any sudden impulse, such as might have been stirred by some unusual happening in the heavens. By the end of the eighteenth century the able successors of Newton had practically completed the investigation of the chief consequences of the law of gravitation, and the technique of observation was so far advanced as to have brought great refinement into the comparison of theory with observation. Astronomical tables had thus reached a high degree of perfection, and the places of the sun, moon, and planets could be predicted with sufficient accuracy for the important practical purposes of navigation and geography. Astronomy had, in fact, come to be regarded as the most perfect and complete as well as the most ancient of all the sciences, but indications are not wanting that this complacent view was tending towards stagnation of effort in what were then considered the more exact departments of the science. The period immediately preceding the foundation of our Society, however, had been far from unproductive in some directions. In particular, the branch of observational astronomy which aims at acquiring a knowledge of the construction of the heavens and of the physical nature of the celestial bodies, had been vastly extended by the labours of Sir William Herschel, whose brilliant discoveries could hardly have failed to stimulate

a wide public interest in our science. Great improvements had also been made in the construction of optical instruments, and numerous amateur observers had been attracted to the systematic observation of celestial phenomena.

The founders of our Society would thus appear to have been influenced solely by a genuine interest in astronomy, and a desire to promote its development in this country. It was very natural that one of the first steps to this end should have been an attempt to establish an institution in which they might meet together in the way which had been found so beneficial in the case of other sciences.

The documents actually in the possession of the Royal Astronomical Society do not enable us to trace the history further back than 1820 January 12, on which day the formation of the Society was definitely resolved upon at a meeting which was held at the Freemasons' Tavern. There is no documentary record to show by whom this meeting was convened, but a fairly complete and probably trustworthy story of the events which led up to it is given in the obituary notice of the Rev. W. Pearson, which appears in vol. viii. of the *Monthly Notices* (1848).* While it is admitted that there is some uncertainty which could not then be cleared up, it was considered highly probable that the prime mover in the formation of the Society was Dr. Pearson. It is stated that "existing documents prove that he [Dr. Pearson] took steps to originate such an institution as early as 1812, and that in this laudable attempt he was assisted by Mr. Troughton, Dr. Kelly, and others, whom we find among our earliest and warmest supporters. In 1816 this proposal had taken so much consistency that Dr. Pearson, at the request of his coadjutors, wrote a preparatory prospectus and address, which were, he says, submitted to Lord Erskine, probably with a view to obtain his Lordship's countenance and influential aid."

The meeting at the Freemasons' Tavern is said to have been resolved upon at a dinner given by Dr. Pearson at East Sheen, and mainly at his suggestion. The writer of the obituary goes on to express his conviction that "the first proposal of an Astronomical Society proceeded from Dr. Pearson, that this proposal was kept steadily in view by him and agitated for several years: and that he was one of the earliest and most zealous members when it was actually constituted."

This account of the events which led to the establishment of the Society is substantiated in all essential details by a letter which was addressed to the President in 1865 by Professor de Morgan, who had joined the Society in 1828, and had for several years acted as Secretary.† Professor de Morgan was then in possession of well-authenticated copies of two letters, the originals of which had been in possession of Captain (afterwards Admiral)

* Attributed to the Rev. R. Sheepshanks by de Morgan, *M.N.*, 26. Mr. Sheepshanks joined the Society in 1825.

† *M.N.*, 26, 18.

Smyth, who had unfortunately never carried out his intention of writing an account of the foundation of the Society. These letters were probably the "existing documents" referred to above, but it is not known what became of them.

The first letter is from Dr. Patrick Kelly to Dr. Pearson, and is dated 1812 December 12. Referring to a forthcoming meeting of schoolmasters, he says: "It may be also a very auspicious time for us to lay some foundation for your suggestion respecting an *Astronomical Society*. I have mentioned it to two or three scientific gentlemen, who all approved very much of the idea: and one in particular, Mr. [Peter] Nicholson, thinks that under good management it might become of great importance to science." In a postscript Dr. Kelly adds: "If the *Astronomical Society* should ever become great, you must not forget that you are the *Father of it*. There are several eminent societies in town possessing inferior objects."

The second letter, dated 1819 December 13, is from Mr. (Sir James) South to Dr. Pearson, giving permission to add the writer's name to a list then in collection, and accepting an invitation to dinner, probably for the express purpose of discussing the proposed Society.

As de Morgan points out, Dr. Pearson thus appears to have kept the plan in his mind from 1812 to 1819, and he adds that his own recollection of what was said in 1830 strengthened the surmise that Dr. Pearson never lost sight of his favourite project, and made a continuous effort to carry it into effect throughout the intervening period.

The claims of Francis Baily to be considered the founder of the Society are scarcely second to those of Dr. Pearson. That Baily was keenly alive to the need for such a Society is indicated by his remarks on the subject in a translation of a paper by Cagnoli, which was printed privately in 1819,* namely:—

> "It is much to be lamented that in this country there is no association of scientific persons formed for the encouragement and improvement of astronomy. In almost all the other branches of the arts and sciences, institutions have been formed for the purpose of promoting and diffusing a general knowledge of those particular subjects . . . the beneficial effects of which are too evident to be insisted on in this place. But astronomy, the most interesting and sublime of all the sciences . . . , cannot claim the fostering aid of any Society. . . . The formation of an *Astronomical Society* would not only afford this advantage, but would in other respects be attended with the most beneficial consequences. . . ."

Some of the surviving original members who had been consulted in 1848 by the writer of the obituary notice of Dr. Pearson

* Memoir on a new and certain method of ascertaining the figure of the earth by means of occultations of the fixed stars, by A. Cagnoli; with notes and an appendix by Francis Baily, London, 1819.

were under the impression that Mr. Baily had the principal share in the actual foundation of the Society. There is certainly much internal evidence of Baily's management, and it is clear that he was one of the chief agents in promoting its constitution and development. The writer of the notice goes on to say that: "But though it may appear clear that, from the first attempt at a union, Mr. Baily took that share of the actual details which he never relinquished, it must not be forgotten that Dr. Pearson was the first to whom it suggested itself that a Society for the promotion of Astronomy was needful and practicable, and was the first who attempted to impress that conviction upon others."

The memorable meeting of 1820 January 12 was called "to take into consideration the propriety and expediency of establishing a Society for the encouragement and promotion of Astronomy." The names of those present are duly entered in the minute-book, and we may well recall them with gratitude to-day. They were:—

Charles Babbage.	J. F. W. Herschel.
Arthur Baily.	Patrick Kelly.
Francis Baily.	Daniel Moore.
Captain Thomas Colby.	Rev. William Pearson.
Henry Thomas Colebrooke.	James South.
Olinthus G. Gregory.	Charles Stokes.
Stephen Groombridge.	Peter Slawinski.

The agreement which was then drawn up and signed by all who attended the meeting does not seem to have been preserved, but it is copied in the minute-book, in Baily's handwriting, and reads as follows:—

> "At a meeting held this twelfth day of January 1820, at the Freemasons' Tavern, London, to take into consideration the advantages that are likely to result from the establishment of a Society for the cultivation of astronomy,—we whose names are hereunto subscribed, being fully aware of the utility of such an Institution, do hereby mutually agree to constitute ourselves a Society, to be called the Astronomical Society of London: and to be guided in our future proceedings by such rules and regulations as may be framed for such Society, in the manner to be appointed at the present meeting for that purpose."

Mr. Baily was appointed secretary *pro tempore*, and a committee was appointed to draw up the regulations for the conduct of the affairs of the Society. This committee was further charged with the preparation of an Address explanatory of the views and objects of the Society, and to circulate it as they might think fit.

The Address, which is printed at the beginning of the first volume of our *Memoirs*, will command the admiration of everyone who reads it.* It sets forth, in dignified language, the useful

* There is a little confusion as to the authorship of the Address. In his memoir of Baily (1844), Sir John Herschel states that "the draft of our rules

objects which might be accomplished, and the impediments which might be removed, by the formation of a Society devoted solely to the encouragement and promotion of astronomy. No better summary of the objects of the original members could be given than that with which the Address concludes, namely: "To encourage and promote their peculiar science by every means in their power, but especially—by collecting, reducing, and publishing useful observations and tables—by setting on foot a minute and systematic examination of the heavens—by encouraging a general spirit of inquiry in practical astronomy—by establishing communications with foreign observers—by circulating notices of all remarkable phenomena about to happen, and of discoveries as they arise—by comparing the merits of different artists eminent in the construction of astronomical instruments—by proposing prizes for the improvement of particular departments, and bestowing medals or rewards on successful research in all—and finally, by acting as far as possible, in concert with every institution, both in England and abroad, whose objects have anything in common with their own: but avoiding all interference with the objects and interests of established scientific bodies."

The first general meeting of the newly constituted Society was held at the rooms of the Geological Society in 1820 February 8, thus establishing our present custom of holding the Anniversary meetings in the month of February. In consequence of the death of His Majesty, King George III., the only business done was the adoption of the Regulations,* and the meeting was adjourned to February 29. Twenty-eight members were then present, and the minutes record the following list of the first Officers, Council, and Trustees of the Society as the unanimous choice of the meeting:—

For President.

His Grace the Duke of Somerset.

For Vice-Presidents.

Henry T. Colebrooke, Esq.
Stephen Groombridge, Esq.
Sir William Herschel.
John Pond, Esq., Astronomer Royal.

For Treasurer.

The Rev. William Pearson, LL.D.

For Secretaries.

Charles Babbage, Esq.
Francis Baily, Esq.
John F. W. Herschel, Esq. (Foreign).

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and the first Address explanatory of our objects, circulated at the commencement of our existence, were entirely, or in great measure, prepared by him." On the other hand, the writer of the obituary of Dr. Pearson (1848) states that the Address was written by Sir John Herschel, "who recollected that Dr. Pearson was active in pressing this duty upon him."

* *Memoirs*, 1, 9–20.

For the Council.

Col. Mark Beaufoy.	Thomas Harrison, Esq.
Cap^{n}. Thomas Colby.	Daniel Moore, Esq.
Dr. Olinthus G. Gregory.	Edward Troughton, Esq.

For Trustees.

Arthur Baily, Esq.
Daniel Moore, Esq.
Charles Stokes, Esq.
} With the Treasurer for the time being.

During the first year of its existence, however, the Society was actually without a President, as the Duke of Somerset withdrew his name before the first ordinary meeting and no other appointment was made until the following February. In a letter to the Council of 1820 March 10, the Duke of Somerset explained, with reference to the last paragraph of the Society's Address, that as Sir Joseph Banks apprehended the ruin of the Royal Society, he felt himself obliged to resign the "flattering hope" of connecting his name with the labours of the Astronomical Society, and that he was under the necessity of withdrawing from the list of members. There is no comment upon this letter in the minutes, and no record of any further action having been taken in the matter. At the same meeting of the Council a letter from Mr. John Fulton was also read, stating that he did not mean to belong to the Astronomical Society, because it did not meet with the approval of Sir Joseph Banks.

It is possible that these letters may throw some light on the difficulties which had been experienced by Dr. Pearson in carrying out his plans for the formation of our Society. They suggest that there may have been some influential opposition to the constitution of additional scientific societies: but any hostility there may have been did not long survive actual experience. In their report to the first annual general meeting in 1821 February 9, the Council were highly gratified to note a reciprocity of feeling on the avoidance of all interference with the objects and interests of other established scientific bodies, which had been expressed "from the chair of the most eminent scientific institution which this or any other country can boast." Another President of the Royal Society —Sir Humphry Davy—had come into office in 1820 November, and his sympathy with the work and aims of the Astronomical Society was further revealed in a letter to the Council in 1821 June 1, in which he returned thanks for an account of the proceedings of the Society which had been sent to him, "in which," he said, "every lover of science must take a strong interest."

The lack of a President, however, was not allowed to interrupt the plans of our founders. The first ordinary meeting of the Society was duly held in 1820 March 10, and others followed on the second Friday of each month throughout the session. So far as can be gathered from the records, the general procedure at these

meetings was not unlike that with which we are all familiar in our own days, but the delights which were derived from the novel opportunities for friendly intercourse are left to our imagination.

The first paper presented to the Society was, very appropriately, one by Dr. Pearson, bearing the title "On the Doubly-refracting Property of Rock Crystal, considered as a principle of Micrometrical Measurements, when applied to a Telescope." Succeeding papers during the first session were not very numerous, but they covered a considerable range of subjects, and were of a character well calculated to enhance the importance and reputation of the Society.

It is not my purpose on the present occasion to attempt to trace in detail the history of our Society further than the first year of its existence, but there are some other matters to which it may be interesting to make brief reference.

I cannot pass without mention the election of Sir William Herschel as the first President of the Society at the first annual general meeting in 1821 February 9. The veteran astronomer was then 82 years of age, and there is no record of his having been present at any meeting of the Council or of the Society. His name, however, shed a lustre upon the Society that will never be effaced, and some indication of his interest in its welfare may be found in the fact that a few months before his death he paid the usual composition fee "in lieu of his future annual payments." Sir Wm. Herschel was succeeded in 1823 by Henry Colebrooke, who was in turn followed successively by Francis Baily in 1825, Sir John Herschel in 1827, and Sir James South in 1829.

Successive annual reports of the Council during these early years show an unbroken chorus of congratulation on the progress, efficiency, and prospects of the Society, and give ample evidence of loyal and untiring efforts to fulfil the purposes for which the Society had been constituted. The membership, including associates, of whom Biot was the first to be elected, steadily rose from 119 in February 1821, to 224 in 1825, and to 277 in 1830. The financial state of the Society was happily never a cause for anxiety, partly because extraordinary expenditure had been in great measure met by the generous voluntary contributions of the members.

The award of medals for distinguished work in astronomy, as proposed in the original Address of the Society, commenced in 1824, when gold medals were awarded to Babbage and Encke, and silver medals to Rümker and Pons. In these early years of the Society's activity, it will be observed, medals were bestowed comparatively freely, but always with great discretion, and never unworthily; and the list of medallists includes some of the most illustrious names in the history of astronomy. The further effort of the Council to encourage the consideration of subjects which might otherwise be neglected, by the award of medals and prizes for the best solutions of definite problems which had been proposed by them, was a source of disappointment. No answers were

received before the specified periods had expired, and in 1828 the proposal of prize questions was abandoned.

The early publications of the Society took the form which has been essentially retained up to the present time. In the first instance, the communications received by the Society were withheld from publication until the end of a year or session so as to form a complete volume, when they appeared as the *Memoirs* of the Society. The disadvantages of this procedure, however, were soon felt, and in 1827 arrangements were finally made for the prompt publication of a series of monthly notices which should contain abstracts of papers, and reports of the proceedings of the Society, while the more complete papers would continue to appear in the *Memoirs*. Our *Monthly Notices* thus came into being, and the new arrangement was found to be of special advantage as providing a suitable means of disposing of matters of temporary interest, such as notices of approaching phenomena, ephemerides of comets, and so on, which did not call for publication in the *Memoirs*. The *Monthly Notices* made their appearance very modestly at first, but gradually grew in relative importance, so that at the present time they include a majority of the papers communicated to the Society.

The estimation in which the early work of the Society was held was expressed by Sir George Airy in his report to the British Association in 1832 on the progress of astronomy during the nineteenth century, where he said that "Astronomy in England has undoubtedly received a strong impulse from the institution of this Society, and the four volumes of *Memoirs* which it has published contain some of the most valuable contributions to astronomy that any country has yet produced."

The question of soliciting a Charter of Incorporation was raised as early as 1825. It was already felt that such an application would be justified by the stability and proved usefulness of the institution, and that a more complete consolidation of the Society would thereby be effected. The first definite step of which there is any record, however, was the Council's decision, in 1830 February 26, that it was expedient to procure a Charter, provided the expense could be defrayed without trespassing on the funds of the Society. A "Charter Committee" was appointed forthwith, and within three months the sum of £382, 18s. had been subscribed.* A petition was duly prepared, but its presentation was deferred until steps had been taken to secure the interest and patronage of His Majesty King William IV. The signature of the King, as Patron of the Society, was inserted in the autograph book in 1830 December 15, and at the meeting of the Society in the following month the change of name from "The Astronomical Society of London" to "The Royal Astronomical Society" was announced by the President, no doubt with becoming pride.

* This sum sufficed to cover all expenses connected with the Charter, and left a balance of £129, 18s. 10d., which, by resolution of the subscribers, was added to the general funds of the Society.

The Charter was graciously signed by the King in 1831 March 7, and thenceforward the members of the Society became "Fellows of the Royal Astronomical Society."

All that now remained for the complete satisfaction of the Society was suitable accommodation, where the members might enjoy the benefits of mutual intercourse and of the use of their library and instruments. In the infancy of its existence, it is recorded, the expenses of the Society were very trifling, owing principally to the liberal spirit exhibited by the Geological Society in granting the use of their rooms, then in Bedford Street, Covent Garden, for the meetings. For this service we shall not fail to retain the due and grateful remembrance which is impressed upon us in the first report of the Council.

In 1820 November the Society removed to Lincoln's Inn Fields, where accommodation had been hired in the apartments of the Medical and Chirurgical Society. The facilities thus provided appear to have given but little satisfaction; but despite continuous attempts during several years to find a more convenient and more permanent home, especially for the rapidly accumulating collections of books and instruments, it was not until the autumn of 1834 that the use of rooms at Somerset House was granted by the Government, chiefly through the efforts of Baily. There the Society was housed until the removal to our present commodious and handsome apartments at Burlington House in 1874.

I shall not now attempt to trace the further history of the Society. To-day we honour the memory of the men who devoted themselves so earnestly and effectively for the foundation of our Society a century ago, and especially of William Pearson and Francis Baily. Each of them belonged to the great body of amateurs to whom British science owes so great a debt, and each faithfully served the institution which they had helped to bring into being.

Dr. Pearson, it may be recalled, was the first Treasurer, and held the office for ten years. His account-books have long disappeared, but beautifully made copies were recently discovered in the library of the late Dr. Lee of Hartwell, and these have been presented to the Society by Mrs. Lee.

Dr. Pearson was an accomplished and zealous observer. His first observatory, equipped with some of the finest instruments then obtainable, was at East Sheen, where he was proprietor of a large preparatory school. In 1817 he was presented to the rectory of South Kilworth, Leicestershire, where he permanently resided after 1821, and carried on his astronomical work with the aid of an assistant. The first volume of Pearson's imposing work, *An Introduction to Practical Astronomy*, was published in 1824, and was dedicated to "The President, Vice-Presidents, and Members at large" of the Astronomical Society. The second volume, containing descriptions and illustrations of instruments, appeared in 1829, and was appropriately dedicated to his friend Edward Troughton, who had done so much for the improvement of

astronomical instruments in this country. For this work Pearson received the Gold Medal of the Society from the hands of Sir John Herschel, who described it as one of the most important and extensive works on the subject which had ever issued from the press. On his death, the remaining copies of the book, which had been published at the author's expense, were bequeathed to the Society, but none now remain. There is no portrait of Pearson in the possession of the Society, but an interesting relic remains in a small clock of peculiar construction,* with features of astronomical interest, which he presented to the Society. He was in his eighty-first year at the time of his death in 1847 September 6.

Francis Baily was Secretary during the first three years, and upon him devolved the chief labour of organising the work of the Society. He was four times President for the usual two-yearly periods, eleven times Vice-President, and until finally prevented by illness he was never absent from a meeting of the Council or of the Society, except in 1836 May 12, when he was away in Scotland to witness an annular eclipse of the sun. In his earlier life Baily was engaged in business as a stockbroker, in which he earned a high reputation and a considerable fortune. He finally retired from business in 1825, when he was 51 years of age, and devoted himself wholly to astronomical pursuits, among which the development of the Astronomical Society was one of the chief. As de Morgan said of him: "Baily was from the very first the guide and stay of the Society, an institution which many might have founded, but few could have nursed."

Baily was less of an observer than Pearson, but his name will be perpetuated in connection with the phenomenon of "Baily's Beads," which he first observed during the annular eclipse in 1836 May 15. He was especially diligent in the collection and reduction of observations, and received the Gold Medal in 1827 for the preparation of the Society's catalogue of 2881 stars.† The improvement of the *Nautical Almanac* in 1829 and the compilation of the *British Association Star Catalogue* ‡ were mainly due to his personal efforts. He rendered a valuable service also by his revision of ancient catalogues of stars.§

Baily's name will also be long remembered for his laborious repetition of the Cavendish experiment for the determination of the mean density of the earth, towards which the Treasury made the liberal grant of £500. A valuable relic of his labours in another direction is the tubular standard scale which is still in the possession of the Society. His portrait by Phillips, presented by Fellows of the Society, hangs in the council-room.

Baily himself could have desired no finer memorial than the memoir written soon after his death by Sir John Herschel, and read at a special general meeting of the Society in 1844 November 8. ||

* This clock is described by Dr. Pearson under "Dial," and is illustrated under "Horology," in Rees' *Encyclopædia*.

† *Memoirs*, **2**. ‡ Published in 1845. § *Memoirs*, **4**.

|| *M.N.*, **6**, 89.

We find the names of nearly all the other original members in the early lists of officers, council, and trustees, and to them also we are greatly indebted for the services they rendered in the infancy of the Society.

The last survivors of the band of men who launched the Royal Astronomical Society were Sir John Herschel and Mr. Babbage, who died within a few months of each other in 1871. They were among the original officers of the Society, and it is a striking fact that not less than fifteen of our present Fellows were elected before they passed away. Our oldest Fellow, Mr. W. B. Gibbs, was elected so long ago as 1857, and has informed me that he remembers having attended at least three meetings at which Sir John Herschel was present, and having on one occasion entered into conversation with him. We can scarcely avoid the conclusion, taking account also of other evidence, that an interest in astronomy is eminently conducive to length of life.

Enough has been said to show that the foundations of our Society were well and truly laid. The purposes for which we are associated are fundamentally the same to-day as they were a hundred years ago, and the regulations originally devised, with modifications in detail rendered necessary by changing conditions, continue to govern our procedure. The work which was commenced so well by our founders has been worthily carried on through succeeding generations, and the Society continues to occupy an honoured place among the scientific institutions of the world.

It remains for us to strive, individually and collectively, to maintain the great traditions of the past, so that in future years we may not be deemed to have been unworthy of our great inheritance.

Election of Officers and Council.

The Meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected:—

President.

Alfred Fowler, Esq., F.R.S., Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.

Vice-Presidents.

Sir F. W. Dyson, M.A., LL.D., F.R.S., Astronomer Royal.
A. S. Eddington, Esq., M.A., M.Sc., F.R.S., Plumian Professor of Astronomy, Cambridge.
Major P. A. MacMahon, D.Sc., Sc.D., LL.D., F.R.S.
H. F. Newall, Esq., M.A., D.Sc., F.R.S., Professor of Astrophysics, Cambridge.

Treasurer.

E. B. Knobel, Esq.

Secretaries.

A. C. D. Crommelin, Esq., B.A., D.Sc.
Rev. T. E. R. Phillips, M.A.

Foreign Secretary.

H. H. Turner, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.

Council.

A. E. Conrady, Esq., Professor of Optical Design, Imperial College, South Kensington.
J. L. E. Dreyer, Esq., M.A., Ph.D.
J. W. L. Glaisher, Esq., Sc.D., F.R.S.
John Jackson, Esq., M.A., B.Sc.
Harold Jeffreys, Esq., M.A., D.Sc.
H. S. Jones, Esq., M.A., B.Sc.
F. A. Lindemann, Esq., M.A., Ph.D., Professor of Experimental Philosophy, Oxford.
E. W. Maunder, Esq.
W. H. Maw, Esq., LL.D.
J. W. Nicholson, Esq., M.A., D.Sc., F.R.S., Professor of Mathematics, King's College.
John H. Reynolds, Esq.
Lieut.-Col. F. J. M. Stratton, M.A., D.S.O.